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A Study of Alternatives for Projected Rotation Dates Used in Navy Enlisted Personnel Distribution

Rodney S. Myers

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Rodney S. Myers

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14. ABSTRACT
Personnel assignments in the Navy frequently result in Sailors being detached from their command before their replacement actually arrives. This practice is referred to as billet "gapping." Conversely, some assignments result in personnel arriving in advance of the detachment of the individual they are replacing, referred to as billet "overlapping." In the case of gapping, the command is expected to accomplish its appointed mission with less than the prescribed personnel. In overlapping, the Navy is essentially paying two Sailors to perform one job. In the former case, the Navy experiences an effectiveness loss; in the latter case the Navy faces an efficiency degradation. Additionally, unplanned losses occur which increase the number of gapped billets. When an unplanned loss occurs in a critical billet, skill area, or rating, commands experiencing the loss are severely challenged to accomplish their mission, particularly war-fighting functions.

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Foreword

This report was prepared as part of the "Study of Alternatives for Projected Rotation Dates Used in Navy Enlisted Personnel Distribution" analysis project sponsored by Navy Personnel Command (NPC).

This report describes the development of a computer simulation model to evaluate billet gaps and overlaps that occur during the follow-on assignment of enlisted personnel. It discusses in detail the operational problem, key modeling assumptions, and analysis results.

Special thanks to each project team member: Mr. David Cashbaugh (NPRST); Mr. Tony Cunningham and Mr. Ilia Christman (N104); Mr. Al Rouse and Mr. Thomas Tilt (Serco, Inc.); Mrs. Geetha Mandava and Mr. James Woods (University of Memphis). Their combined functional and technical knowledge contributed to the success of this effort.

David L. Alderton, Ph.D.
Director

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Introduction

Abstract

Personnel assignments in the Navy frequently result in Sailors being detached from their command before their replacement actually arrives. This practice is referred to as billet "gapping." Conversely, some assignments result in personnel arriving in advance of the detachment of the individual they are replacing, referred to as billet "overlapping." In the case of gapping, the command is expected to accomplish its appointed mission with less than the prescribed personnel. In overlapping, the Navy is essentially paying two Sailors to perform one job. In the former case, the Navy experiences an effectiveness loss; in the latter case the Navy faces efficiency degradation. Additionally, unplanned losses occur which increase the number of gapped billets. When an unplanned loss occurs in a critical billet, skill area, or rating, commands experiencing the loss are severely challenged to accomplish their mission, particularly war-fighting functions.

The problem under analysis is characterized as available Sailor inventory versus billet requirements during the period of time known as the assignment window. The current policy for the assignment window is the period commencing 9-months prior to a Sailor's planned rotation date (PRD). During this 9-month period, detailers[3]evaluate a Sailor for follow-on job assignments. However, the job a Sailor ultimately receives is subject to the demand for his or her skills (i.e., rate, rating, Navy Enlisted Code, etc.), when a Sailor is available for reassignment, and the available jobs. The 9-month assignment window allows the detailer, Sailor, and commands time to negotiate the Sailor's ensuing assignment. Other constraints associated with transferring a Sailor (e.g., financial) should be analyzed separately using an operational tool such as the Assignment Policy Management System (APMS)[4]. The analysis does not consider a Sailor's individual skill or paygrade; but does assume a higher priority for Sailors who have been awaiting assignment for the longest period of time. Although skills, paygrade, choice, training, and move costs are direct factors influencing Sailor-job assignment, they were not explicitly modeled here.

This report describes the development of a computer simulation called the *Rotation Window Analysis Model*. The model was developed to analyze the impact of an assignment window on the enlisted detailing process. Through the development of the simulation model, analysis of the probable impact of adjusting Sailor PRDs was evaluated.

[3] A "detailer" is the person responsible for making Navy job assignments.
[4] Benson, T. (2002). *Assignment Policy Management System (APMS): A Decision Support Tool for Application in the Distribution and Assignment Department in the Navy Personnel Command* (NPRST-TN-02-6). Millington: Navy Personnel Research, Studies, and Technology Department.

Objective

The objective of this modeling effort was to test a hypothesis which states "if detailers make use of the existing policies that allow adjustment of Sailor PRDs, then on-time assignments will increase and overlapped and gapped billets will decrease in frequency and length."

Introduction

The Rotation Window Analysis Model is a continuous time-based, closed-loop simulation that includes stochastic variables for producing random behavior where the simulation time step dimension is months. The model contains an array of Sailors and an array of Billets. Sailor characteristics are Sailor identification number, PRD, sea or shore assignment, the billet identification number, the TUM of the current billet to which the Sailor is assigned, and assigned or unassigned status. Billet characteristics are: billet identification number, TUM, sea or shore duty, vacant or filled status, and number of Sailors currently occupying a billet. It allows the user to specify early rotation and late rotation policies for sea and shore separately, total number of Sailors vs. billets to evaluate for sea and shore separately, maximum allowable Sailors per billet, allowable overlap before a Sailor is considered for a back-to-back assignment, allowed percentage of back-to-back assignments, allowable overlap before being moved to non-distributable inventory (NDI), months to simulate, range of detailing window, tour lengths for sea and shore, and length of reporting delay.

Each simulated month, Sailors within the assignment window are considered for available billets based on assignment policies. Sailors are considered for a follow-on assignment as a rotational assignment, a back-to-back assignment, or move to NDI. Assignments are subject to: Sailor versus billet availability, period of overlap, back-to-back assignment policy, reporting delays, and early-late rotation policy. Reporting delays represent the time delay between when a Sailor vacates the current billet and arrives at the new billet. An early rotation is the amount of time allowed by policy, for a Sailor to report to a billet prior to his or her PRD; a Sailor with a PRD in October could accept a job with a TUM in August and be considered on-time if the early rotation policy is at least 2-months and the delay is 0-months. Conversely, a late rotation is the amount of time allowed by policy for a Sailor to report to a job after the PRD; a Sailor with a PRD in October could accept a job with a TUM in December and be considered on-time if the late rotation policy is at least 2-months and the delay is 0-months. Early and late rotation policy allows detailers to adjust a Sailor's PRD to avoid creating a gap or overlap. The period of overlap is the amount of time a Sailor remains in his or her current billet after their relief arrives, thus two Sailors are occupying a single billet. If a Sailor has not received an assignment and has been occupying a billet beyond the allowable time after their relief has arrived, the Sailor is moved to a NDI status, which is the very last option.

The model contains four uniformly distributed random variables. Two random variables are used to initialize the PRDs and TUMs for the initial inventory of Sailors and billets. A random variable is generated to determine if a Sailor can be assigned to a back-to-back tour, subject to the policy set by the user. The final random variable is used

to generate reporting delays based on the user specified range. Users can enable or disable randomization of the initial PRD, TUMs, and reporting delay variables.

The simulation is a closed-loop, where the total number of Sailors and billets remain constant for the duration of a simulation run; Sailors are neither added nor lost. However, the number of Sailors assigned and the percentage assigned to sea or shore will vary. This model assumption is justified because policy decisions are based on current inventories of Sailors and billets.

The model's interface provides a summary of the simulation results, updated at the end-of each simulated month (see Appendix A, Figure A-1). The inventory of Sailors and billets can be viewed from the "inventory" tab (see Appendix B, Figure B-1). A complete summary of each assignment is viewable on the "results" tab (see Appendix C, Figure C-1).

Estimating Output Precision

Sound practice dictates that a minimum of three simulation replications be used to determine the variance of the variables (Law & Kelton, 2000). Following the initial three replications, Equation 1 was used to determine the number of additional replications required to meet a specified error (e.g., 5%) or level of precision (e.g., 95%).

Equation 1: $n_a^*(\beta) = \min\{i \geq n : t_{i-1,1-\alpha/2} \frac{\sqrt{S^2}(n)}{i} \leq \beta \}$

Equation 2: $S^2(n) = \frac{\sum_{i=1}^{n}[X_i - \overline{X}(n)]^2}{n-1}$

The colon is read such that: $n_a^*(\beta)$ is determined by iteratively increasing *i* by 1 until a value of *i* is obtained where $t_{i-1,1-\alpha/2} \frac{\sqrt{S}^2(n)}{i} \leq \beta$. Variable estimates following *i* replications should have an absolute error of β. The accuracy of Equation 1 depends on how close the variance estimate $S^2(n)$ is to the true $Var(X)$.

Analysis

The following is based on varying manning percentages, rotation window policy, and tour lengths. The output precision is based on a 95 percent confidence interval (i.e., 5% error). For simplicity the number of billets for sea and shore assignments were constant (100 billets), and inventory of Sailors was adjusted to create the desired manning percentage. Since the model is stochastic, it was replicated several times per scenario. Criterion for model replications is based on Equation 1. Tables 1 and 2 represent the increase in on-time assignments, based on varying assignment window sizes. Default model settings are: 100 billets for sea and shore respectively, maximum of 2 Sailors per billet, 3 months allowable overlap before a Sailor is considered for a back-to-back assignment, only 5 percent overall back-to-back assignments (sea and shore),

randomized initial PRDs and TUMs, and random reporting delays with a range of 0–3 months. The tour lengths for Table 1 were held constant at 36 months for both sea and shore assignments.

Table 1
Window size

Manning %	Window Range	On-time Assignments Increase
100%	0–3	62%
94%	0–3	2%
85%	0–3	2%
75%	0–3	2%
100%	4–6	24%
94%	4–6	12%
85%	4–6	2%
75%	4–6	1%

Current policy for adjusting PRDs is +3/-4 (early/late). In each model scenario the window size was evenly lengthened by one month for sea-shore and early-late variables. Once the output appeared steady for two consecutive window sizes, no additional window sizes were considered because further increasing the window size returned slight, if any, changes in the assignment trend. Tables 1 and 2 display percentage increase in on-time assignments for varying manning percentages and window ranges. See Appendixes D and E for graphic representation of the data for the analysis conducted. Table 1 shows the greatest increase in on-time assignments were for the 100 percent manned case with a window range of 0–3 months. Although on-time assignments increased when the window size was increased to 4–6 months, the magnitude of increases was reduced except for the 94 percent manning level. Generally, expanding the window beyond 3 months did produce substantial increases in on-time assignments.

Table 2
Tour length

Manning %	Window Range	Sea Tour Length	Shore Tour Length	On-time Assignments Increase
100%	0–3	36	30	23%
94%	0–3	36	30	33%
85%	0–3	36	30	7%
75%	0–3	36	30	2%
100%	4–6	36	30	16%
94%	4–6	36	30	3%
85%	4–6	36	30	10%
75%	4–6	36	30	2%

Table 2 demonstrates an increase in on-time assignments by expanding the window size with reduced shore tours (i.e., 30-months vs. 36-months). Again, expanding the window size beyond 3 months reduces the magnitude of increases, with the exception of the 85 percent manned case.

Conclusions and Recommendations

These simulations and analyses demonstrate that adjusting PRDs does increase the likelihood of members reaching their follow-on job on time. It also demonstrates that marginal improvements to on time arrivals is a decreasing function whose maximum utility appears to peak around the PRD window size of three months. The optimal length of the window should be determined through further analysis using test cases involving active assignments. Tour lengths and allowable back-to-back assignment policy are likely influences on assignment accuracy and should be further analyzed as well.

Recommend Pers-4 direct detailers to utilize existing policies, which allow adjustment of Sailor PRDs.

Appendix A:
Model Interface

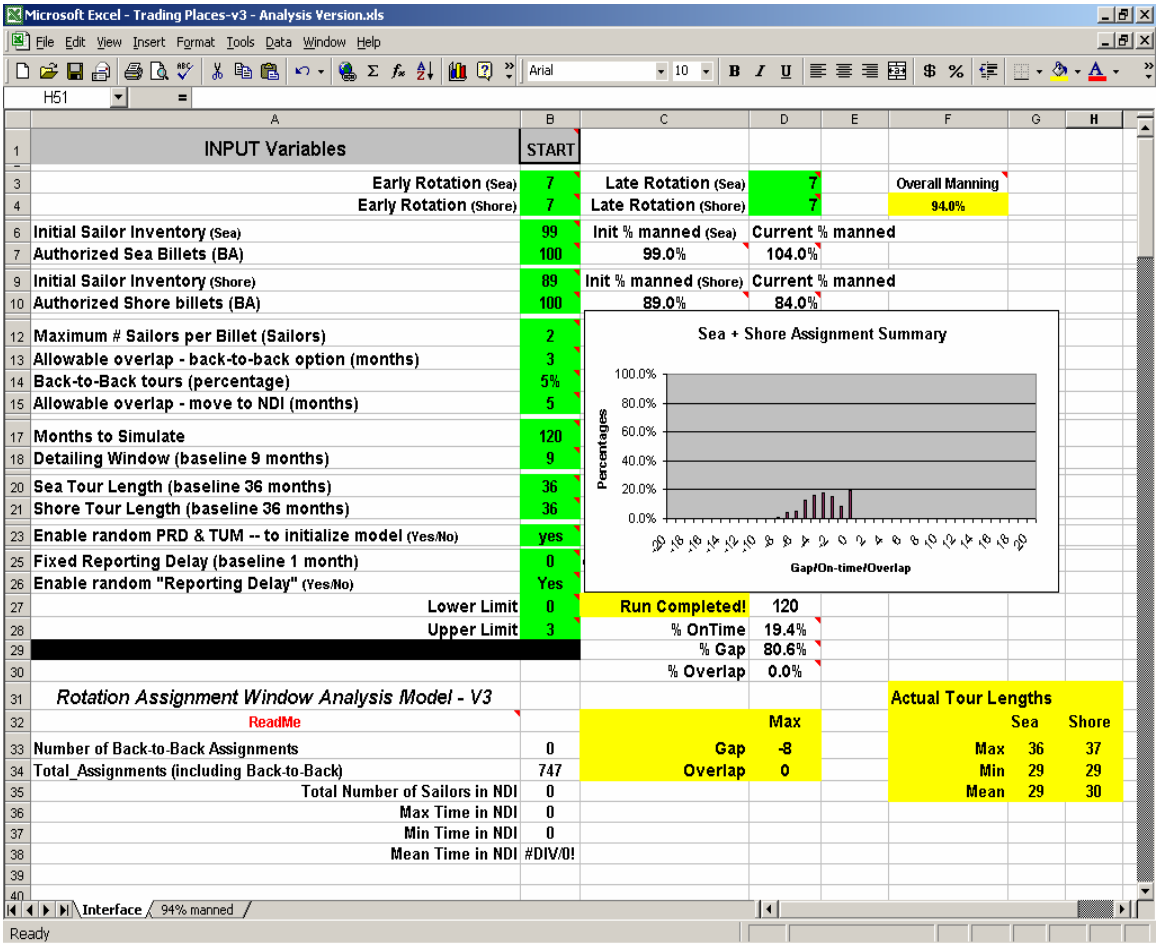
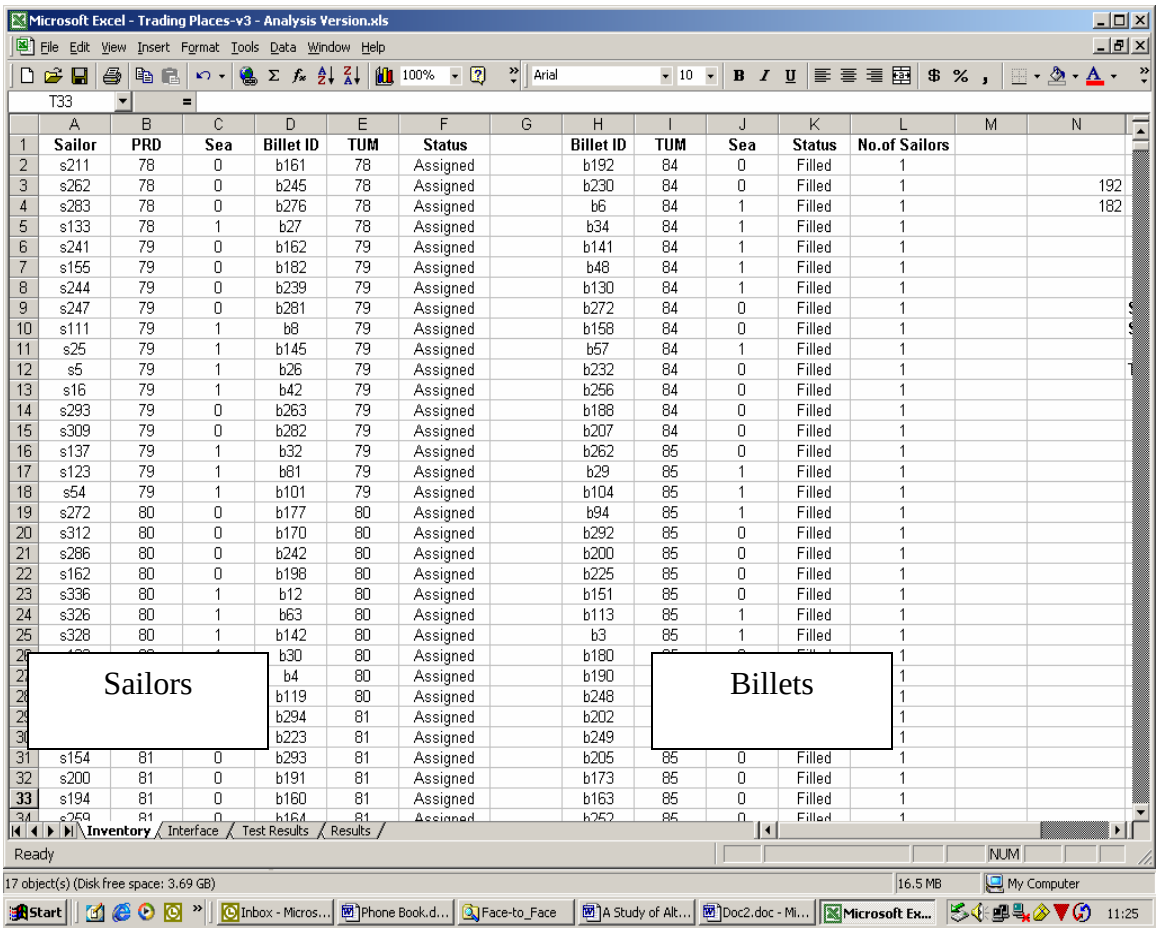


Figure A-1. Model interface.

Appendix B:
Sample “Inventory”



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Sailor	PRD	Sea	Billet ID	TUM	Status		Billet ID	TUM	Sea	Status	No.of Sailors		
2	s211	78	0	b161	78	Assigned		b192	84	0	Filled	1		
3	s262	78	0	b245	78	Assigned		b230	84	0	Filled	1		192
4	s283	78	0	b276	78	Assigned		b6	84	1	Filled	1		182
5	s133	78	1	b27	78	Assigned		b34	84	1	Filled	1		
6	s241	79	0	b162	79	Assigned		b141	84	1	Filled	1		
7	s155	79	0	b182	79	Assigned		b48	84	1	Filled	1		
8	s244	79	0	b239	79	Assigned		b130	84	1	Filled	1		
9	s247	79	0	b281	79	Assigned		b272	84	0	Filled	1		
10	s111	79	1	b8	79	Assigned		b158	84	0	Filled	1		
11	s25	79	1	b145	79	Assigned		b57	84	1	Filled	1		
12	s5	79	1	b26	79	Assigned		b232	84	0	Filled	1		
13	s16	79	1	b42	79	Assigned		b256	84	0	Filled	1		
14	s293	79	0	b263	79	Assigned		b188	84	0	Filled	1		
15	s309	79	0	b282	79	Assigned		b207	84	0	Filled	1		
16	s137	79	1	b32	79	Assigned		b262	85	0	Filled	1		
17	s123	79	1	b81	79	Assigned		b29	85	1	Filled	1		
18	s54	79	1	b101	79	Assigned		b104	85	1	Filled	1		
19	s272	80	0	b177	80	Assigned		b94	85	1	Filled	1		
20	s312	80	0	b170	80	Assigned		b292	85	0	Filled	1		
21	s286	80	0	b242	80	Assigned		b200	85	0	Filled	1		
22	s162	80	0	b198	80	Assigned		b225	85	0	Filled	1		
23	s336	80	1	b12	80	Assigned		b151	85	0	Filled	1		
24	s326	80	1	b63	80	Assigned		b113	85	1	Filled	1		
25	s328	80	1	b142	80	Assigned		b3	85	1	Filled	1		
26				b30	80	Assigned		b180				1		
27				b4	80	Assigned		b190				1		
28				b119	80	Assigned		b248				1		
29				b294	81	Assigned		b202				1		
30				b223	81	Assigned		b249				1		
31	s154	81	0	b293	81	Assigned		b205	85	0	Filled	1		
32	s200	81	0	b191	81	Assigned		b173	85	0	Filled	1		
33	s194	81	0	b160	81	Assigned		b163	85	0	Filled	1		
34	s259	81	0	b164	81	Assigned		b252	85	0	Filled	1		

Figure B-1. Sample inventory.

Appendix C:
Sample “Results”

Microsoft Excel - Trading Places-v3 - Analysis Version.xls

Month	Sailor	Current Billet	Exp_Loss Date	To Sea	Exp-Date-of-Arrival	New Billet	Assignment	Ovlp/Gap	Reporting Delay	Actual T
1	s17	b17	1	0	1	b171	On-Time	0	2	
1	s80	b80	1	0	1	b172	On-Time	0	1	
1	s90	b110	1	1	1	b81	On-Time	0	1	
1	s94	b114	1	1	1	b82	On-Time	0	3	
1	s92	b112	1	1	1	b83	On-Time	0	0	
1	s109	b129	1	1	1	b84	On-Time	0	3	
1	s3	b3	1	0	1	b173	On-Time	0	0	
1	s67	b67	1	0	1	b174	On-Time	0	1	
1	s131	b151	1	1	1	b85	On-Time	0	1	
1	s149	b169	1	1	1	b86	On-Time	0	0	
1	s44	b44	1	0	2	b175	Gap	-2	3	
1	s52	b52	1	0	1	b176	On-Time	0	0	
1	s68	b68	1	0	2	b177	Gap	-2	3	
1	s111	b131	1	1	1	b87	On-Time	0	0	
1	s47	b47	1	0	3	b178	Gap	-3	3	
1	s60	b60	1	0	2	b179	Gap	-2	2	
1	s79	b79	1	0	1	b180	On-Time	0	0	
1	s129	b149	1	1	1	b88	On-Time	0	1	
1	s135	b155	1	1	1	b89	On-Time	0	0	
1	s142	b162	1	1	2	b90	Gap	-2	2	
1	s30	b30	1	0	2	b181	Gap	-2	1	
1	s78	b78	1	0	3	b182	Gap	-3	2	
1	s133	b153	1	1	1	b91	On-Time	0	0	
1	s28	b28	2	0	2	b183	Gap	-2	0	
1	s48	b48	2	0	4	b184	Gap	-4	2	
1	s118	b138	2	1	4	b92	Gap	-4	2	
1	s14	b14	3	0	6	b185	Gap	-6	3	
1	s98	b118	3	1	3	b93	Gap	-3	0	
1	s100	b120	3	1	3	b94	Gap	-3	0	
1	s106	b126	3	1	3	b95	Gap	-3	0	
1	s112	b132	3	1	5	b96	Gap	-5	2	
1	s123	b143	3	1	4	b97	Gap	-4	1	
1	s32	b32	4	0	4	b186	Gap	-4	0	
1	s38	b38	4	0	5	b187	Gap	-5	1	
1	s39	b39	4	0	6	b188	Gap	-6	2	
1	s139	b159	4	1	4	b98	Gap	-4	0	

Interface / 75% manned / Results

Ready

Figure C-1. Sample results.

Appendix D:
Assignment Graphs

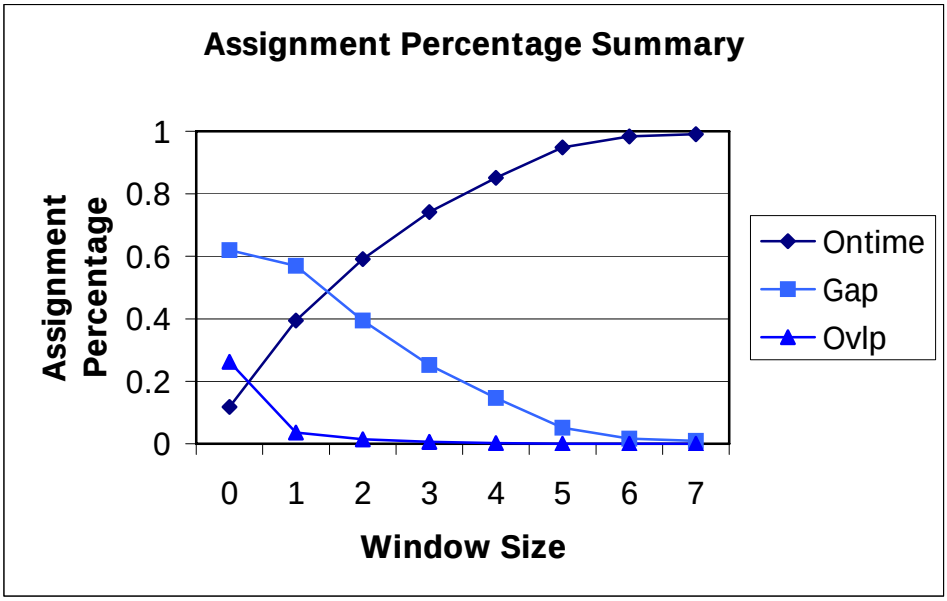


Figure D-1. 100% Manned—Assignment percentages.

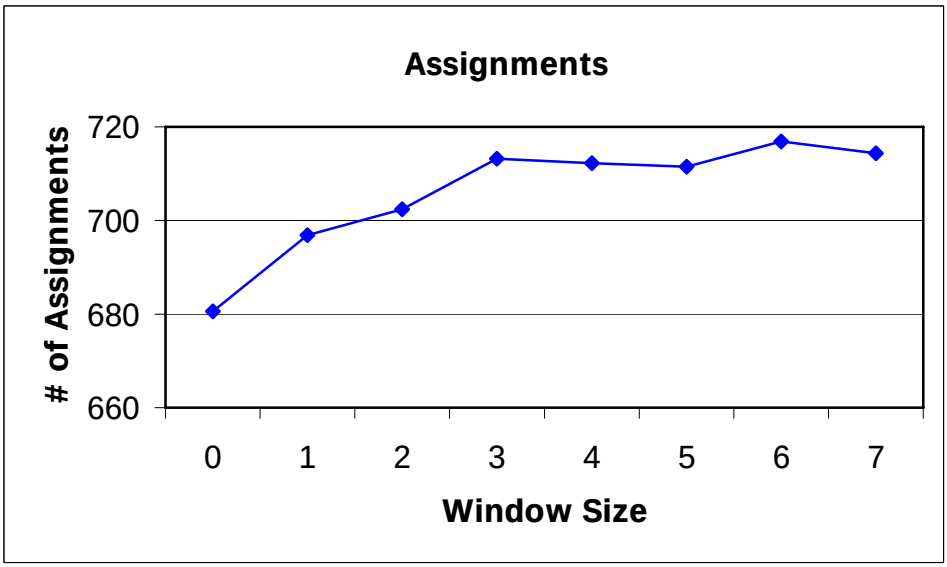


Figure D-2. 100% Manned—Number of assignments.

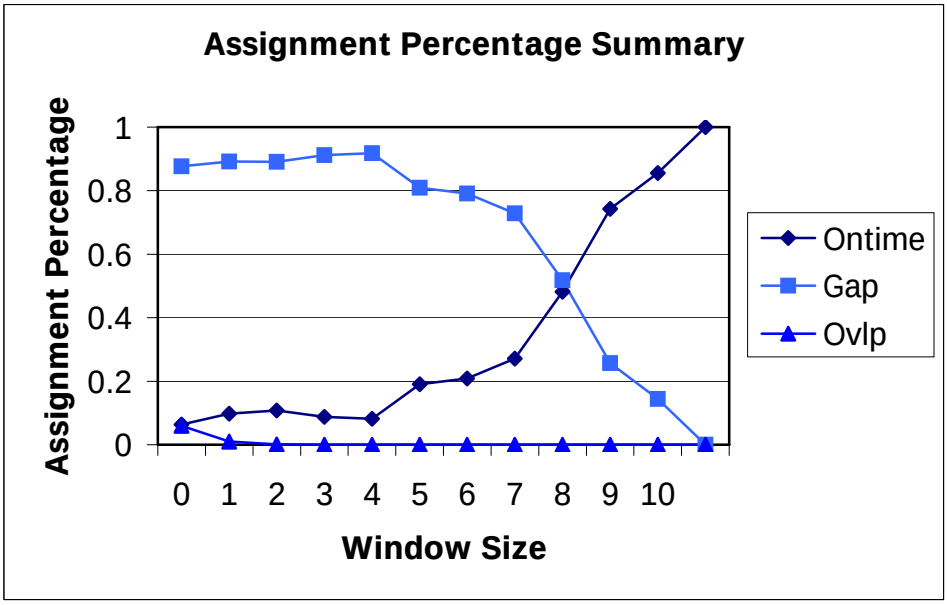


Figure D-3. 94% Manned—Assignment percentages.

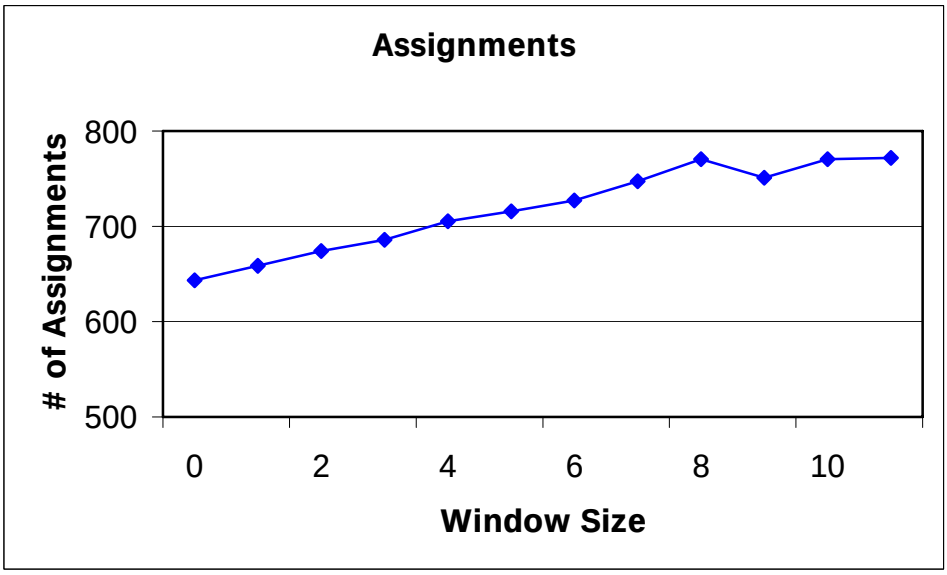


Figure D-4. 94% Manned—Number of assignments.

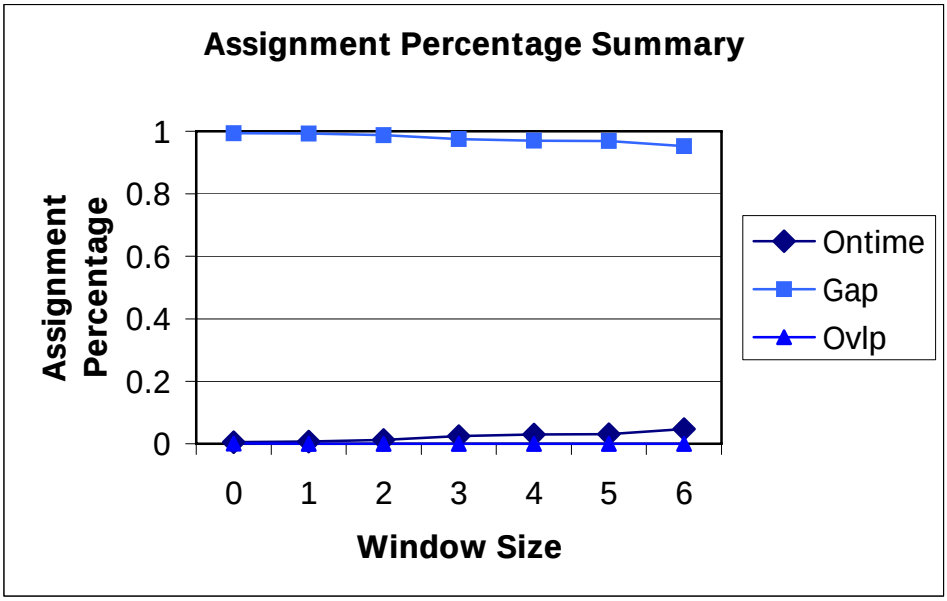


Figure D-5. 85% Manned—Assignment percentages.

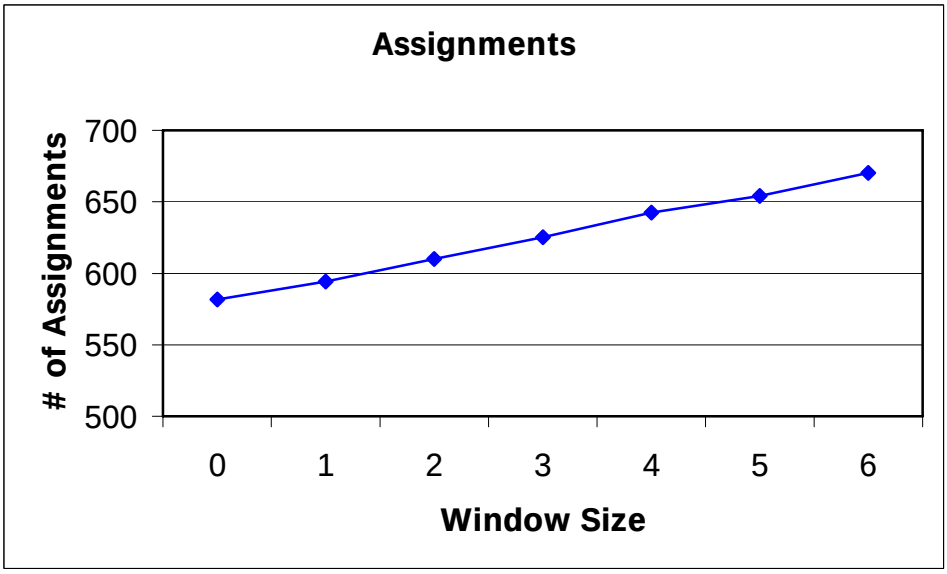


Figure D-6. 85% Manned—Number of assignments.

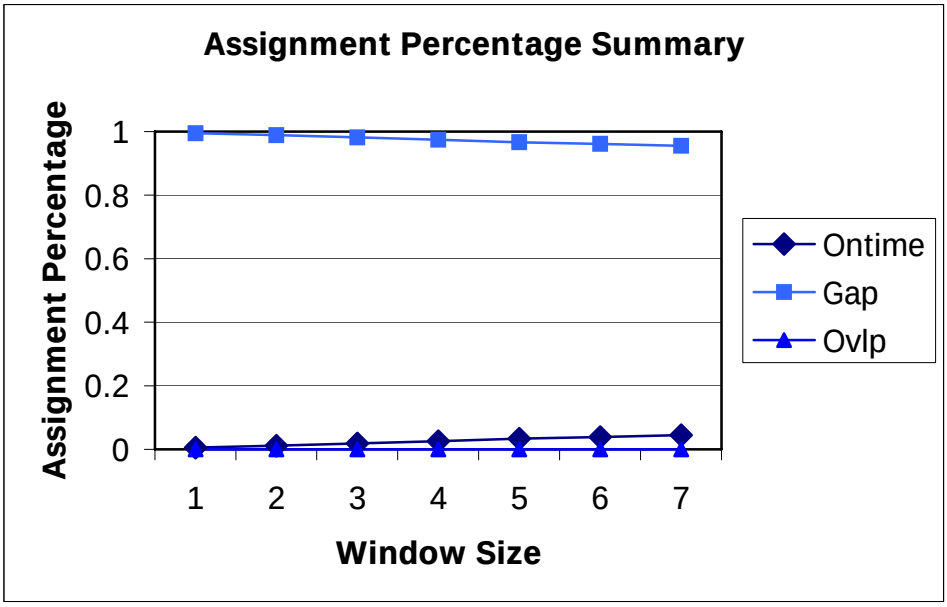


Figure D-7. 75% Manned—Assignment percentages.

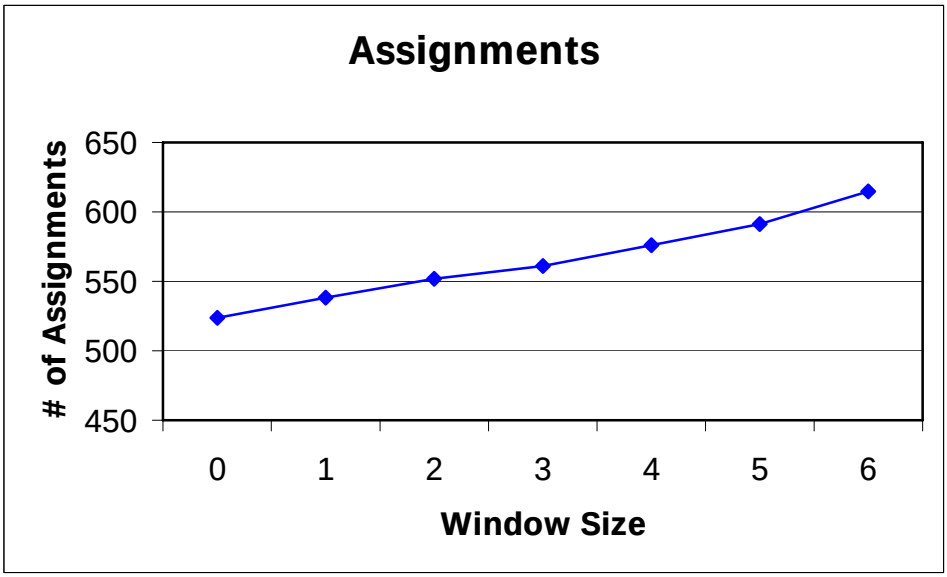


Figure D-8. 75% Manned—Number of assignments.

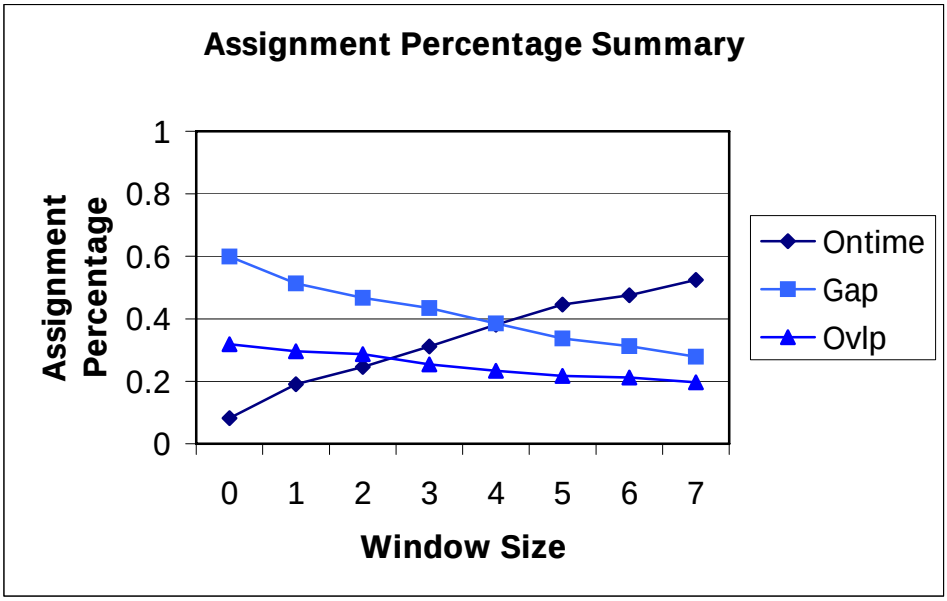


Figure D-9. 100% Manned—36/30 tour lengths.

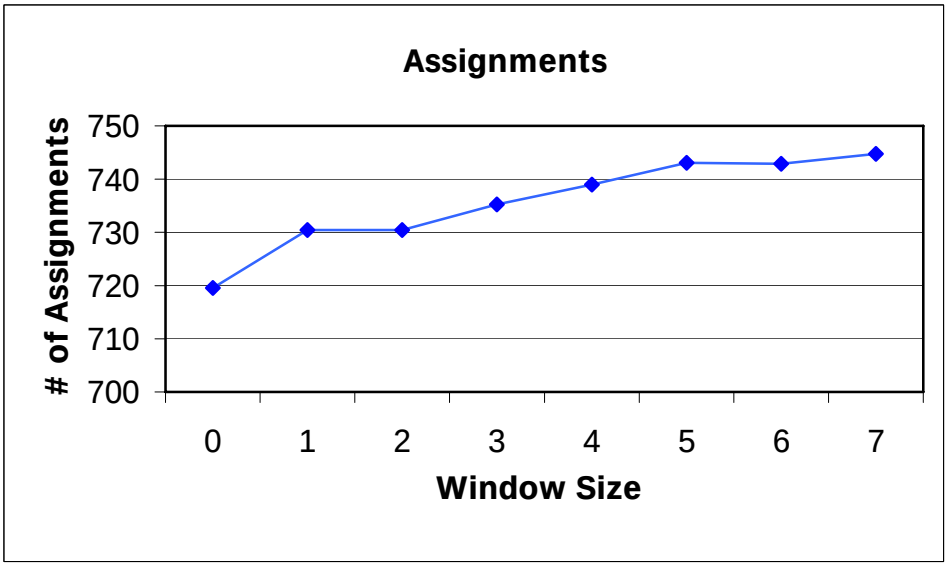


Figure D-10. 100% Manned—36/30 tour lengths.

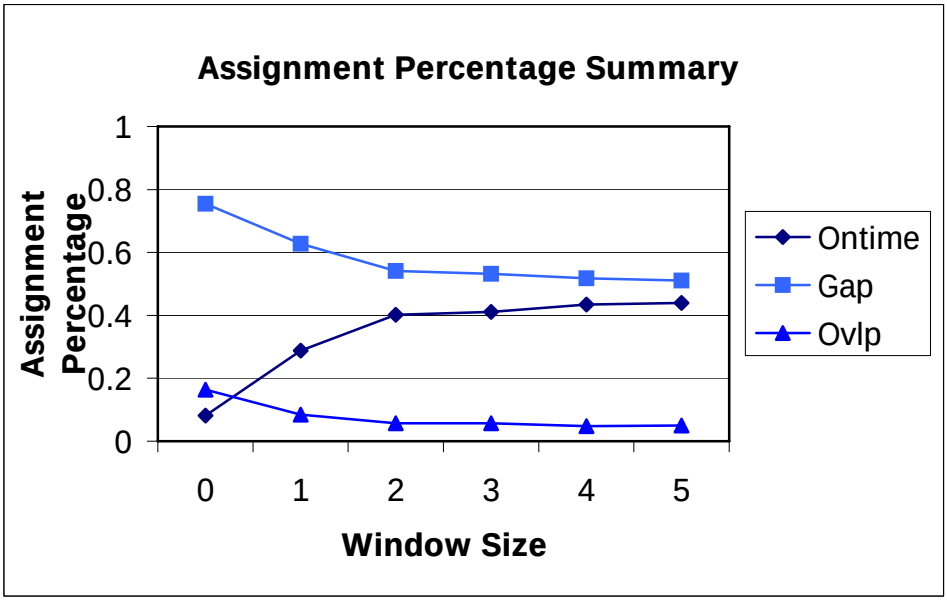


Figure D-11. 94% Manned—36/30 tour lengths.

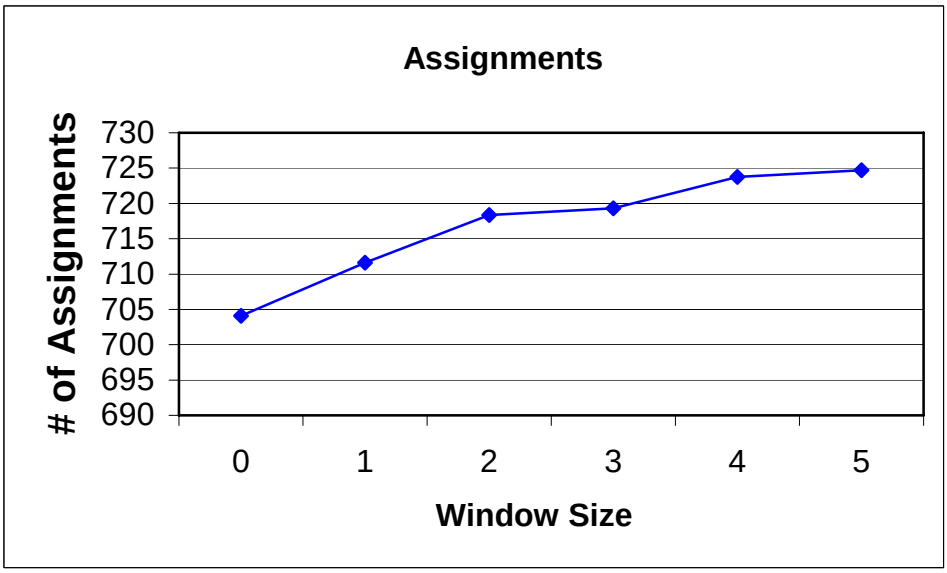


Figure D-12. 94% Manned—36/30 tour lengths.

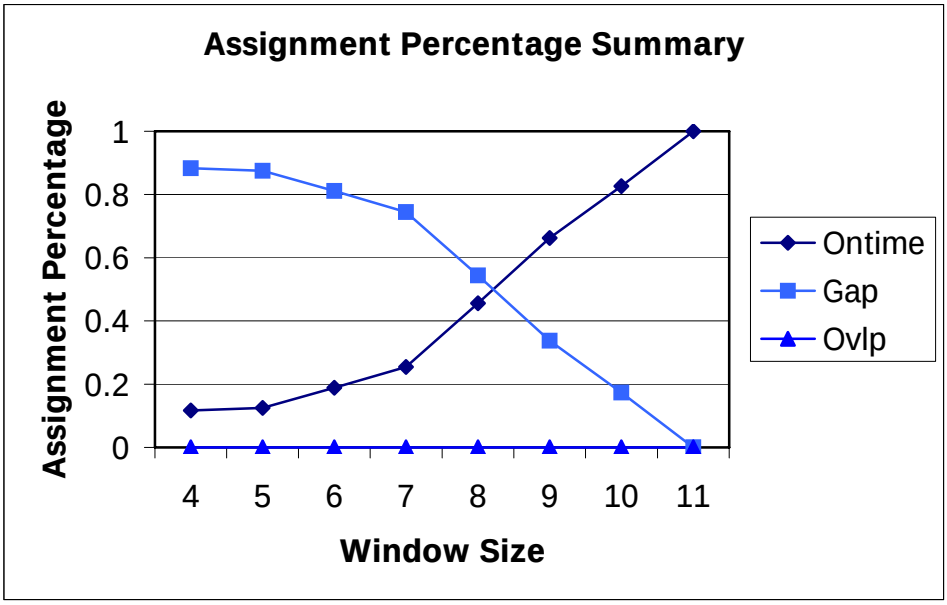


Figure D-13. 85% Manned—36/30 tour lengths.

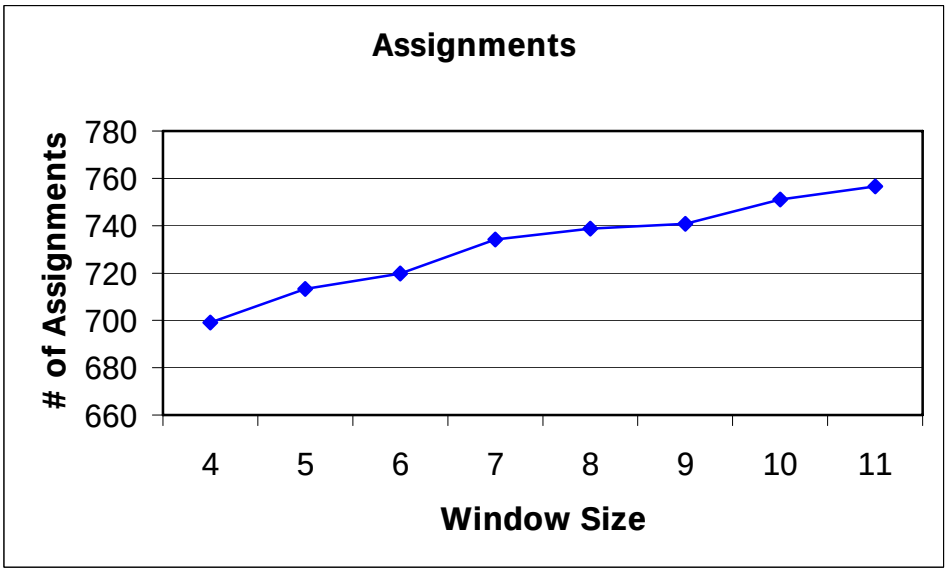


Figure D-14. 85% Manned—36/30 tour lengths.

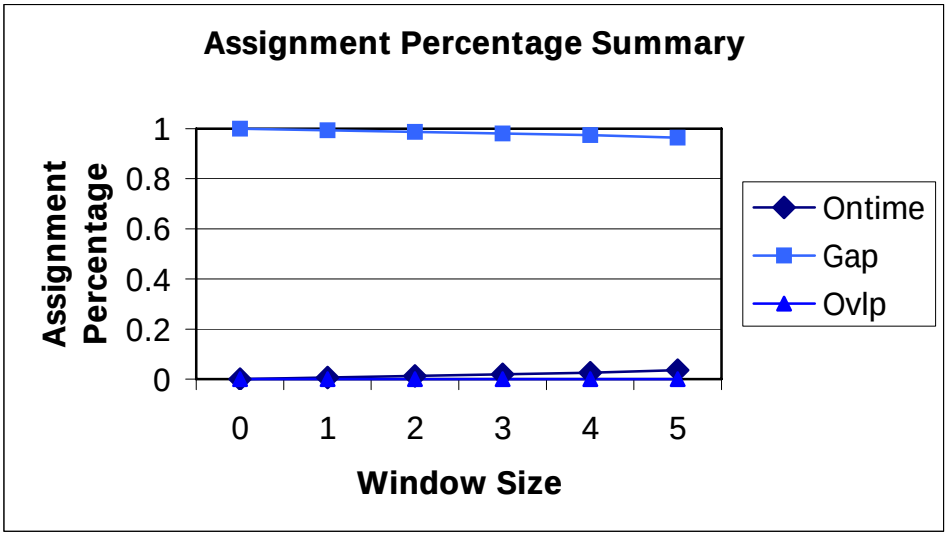


Figure D-15. 75% Manned—36/30 tour lengths.

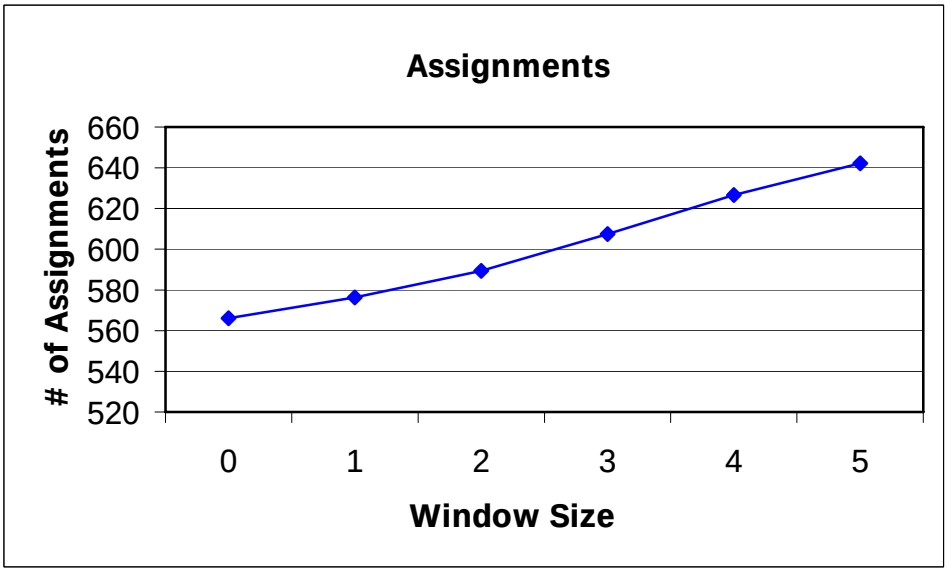


Figure D-16. 75% Manned—36/30 tour lengths.

Appendix E:
Output Precision Tables

Table E-1
100% manned—36/36 tour lengths

Window	Replications	Test Value
0	7	0.04329
1	29	0.02786
2	7	0.04329
3	10	0.00155
4	17	0.01472
5	15	0.02818
6	16	0.04195
7	19	0.00248

Table E-2
94% manned—36/36 tour lengths

Window	Replications	Test Value
0	15	0.03354
1	16	0.02728
2	13	0.04027
3	11	0.02443
4	7	0.00271
5	7	0.01082
6	31	0.00029
7	10	0.00155
8	43	0.01547
9	34	0.01150
10	11	0.00611
11	36	0.00330

Table E-3
85% manned—36/36 tour lengths

Window	Replications	Test Value
0	16	0.00109
1	9	0.00265
2	11	0.02956
3	10	0.02486
4	18	0.01893
5	10	0.00039
6	7	0.00271

Figure E-4
75% manned—36/36 tour lengths

Window	Replications	Test Value
0	9	0.03240
1	12	0.01310
2	10	0.04699
3	16	0.03929
4	15	0.00984
5	15	0.00984
6	15	0.04245
7	11	0.01564

Figure E-5
100% manned—36/30 tour lengths

Window	Replications	Test Value
0	14	0.01558
1	11	0.00611
2	21	0.00191
3	11	0.00220
4	6	0.00000
5	23	0.01741
6	11	0.02443
7	22	0.04048

Figure E-6
94% manned—36/30 tour lengths

Window	Replications	Test Value
0	18	0.02109
1	8	0.03098
2	11	0.01197
3	13	0.03224
4	17	0.00365
5	15	0.00380

Figure E-7
85% manned—36/30 tour lengths

Window	Replications	Test Value
0	17	0.00205
1	7	0.01082
2	12	0.00016
3	10	0.00039
4	16	0.00279
5	7	0.01082
6	10	0.02486
7	6	0.00797
8	15	0.01985
9	11	0.00098
10	18	0.00584
11	10	0.01398

Figure E-8
75% manned—36/30 tour lengths

Window	Replications	Test Value
0	6	0.00797
1	15	0.00775
2	10	0.01903
3	7	0.02435
4	16	0.04105
5	11	0.00220

Appendix F:
Glossary of Terms

Glossary of Terms

Allowable Overlap—Represents the allowable time beyond the current month where a Sailor would be allowed to remain in the current before moving to NDI. This applies only when the number of Sailors/billets is at maximum in this simulation.

Assignment—A Sailor being matched to a job (billet).

Assignment policy—The policy rules governing a Sailor/billet assignments. Referred to as early or late rotation policy.

Assignment window—The period of time where Sailors and detailers negotiate for orders (also known as Orders Negotiation Window in the MLPS Manual).

Authorized Sea or Shore Billets—Total number of billets for this simulation.

Back-to-back assignment—An assignment where the Sailor transfers from a sea billet to another sea billet or a shore billet to another shore billet.

Billet—A Navy job authorized by Congress.

Billet ID—A unique value or identification assigned to each billet for this simulation.

Billet Status—Denotes whether a billet is vacant or filled in this simulation.

Detailer—The individual who represents the Sailor in the coordination of their follow-on assignment.

Diminishing Marginal Returns—The principle that as more of any good or service is consumed, its extra benefit declines. Otherwise stated, there are smaller and smaller increases in total utility from the consumption of a good or service as more is consumed during a given time period.

Expected Arrival Date— Date a Sailor is expected to arrive at a new billet.

Expected Loss Date—Date a Sailor is expected to vacate the current billet.

Gapped billet—The case when a Sailor is detached from their billet before the relief actually arrives.

Initial Inventory—Specifies the initial number of Sailors filling billets for this simulation.

Months to Simulate—Specifies the duration of the simulation run dimensioned in months.

Non-Distributable Inventory (NDI)—The classification for Sailors who are not occupying a functional Navy billet, also known as the individuals' account.

Number of Sailors—The number of Sailors assigned to a billet.

On-Time assignment—The case when a Sailor is detached from a billet at the same time relief arrives.

Overlap billet—The case when a Sailor arrives in advance of the detachment of the individual they are replacing.

Planned Rotation Date (PRD)—A future date, when the Sailor is expected to transfer to the next assignment.

Reporting Delay—The fixed time between a Sailor vacating a billet and arriving at the next duty station used for this simulation.

Rotational assignment—An assignment where the Sailor rotates from a sea billet to a shore billet or vise versa.

Sailor ID—Unique value or identification assigned to each Sailor for this simulation.

Sailor Status—Denotes whether a Sailor is assigned to a billet or not in this simulation.

Sea/Shore Tour Length—Specifies the sea/shore tour length during the simulation run for all new assignments.

Take-up-month (TUM)—A future date when a billet is expected to become vacant.

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