OPTIMIZATION OF SMALL PACKAGE SORTING FOR UNITED PARCEL SERVICE

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ABSTRACT

United Parcel Service's Dallas ground hub currently uses inefficient sorting methods in their small sort. UPS engineers developed time measurement units which measure the time, energy, and effort placed into performing a certain task. Time measurement units or TMUs are arranged in an inward to outward method which signifies that the effort to place an item directly in front of a person is less than the effort to reach onto a high shelf. Taking this into consideration, along with the fact that most sorters in the small sort are petite women whose heights do not exceed five feet and two inches, and combining this with the percentage to total volume of the small sort area, a new bin scheme is formulated. The new bin scheme ranks each destination according to the percentage to the total small sort volume, and then reassigns the destination to a new location within the bin scheme. The new bin scheme saved an average of 18.61% in the most optimal position and reduced the least optimal position by an average of 17.93%.

SECTION 1 – INTRODUCTION

1.1– United Parcel Service

In 1907 nineteen year old Jim Casey borrowed one hundred dollars to establish a messenger service in Seattle, Washington. He named it American Messenger Service which preformed tasks such as delivering messages, packages, and food from restaurants. The year 1913 brought about improvements such as the acquisition of a Model T Ford for deliveries, the idea of consolidated delivery where packages destined for one area would be placed on one truck, and a new name. American Messenger Service was now called Merchants Parcel Delivery since it was now geared toward deliveries for department stores. It quickly became a well respected company and in 1919 it became United Parcel Service to establish its unity and nature of business.

UPS has continually been the trendsetter. In 1929 UPS was the first to provide air service, and in 1981 they bought their first airplane. UPS implemented the first electronic ground tracking system in 1992, and in 1994 www.ups.com went live with customers tracking packages online. The Delivery Information Acquisition Devise (DIAD) was given to each driver in 1996 which provided real-time images of the receiver's signature to the sender.

Currently, UPS is a thirty billion dollar corporation which employs over 380,000 worldwide. Every day they deliver 14.1 million packages and documents to more than 200 countries and territories. Averages of ten million online tracking requests are made on www.ups.com which receives 145 million hits per day.

United Parcel Service is committed to diversity in the workplace. In fact, UPS has been named "One of the Best 50 Companies for Minorities" by FORTUNE Magazine every year for the past seven years. UPS understands the importance of giving back to the community and partners up with many organizations such as INROADS which provides internships to minorities, Family and Workplace Literacy Programs, and the Special Olympics.

1.2– Dallas Ground Hub

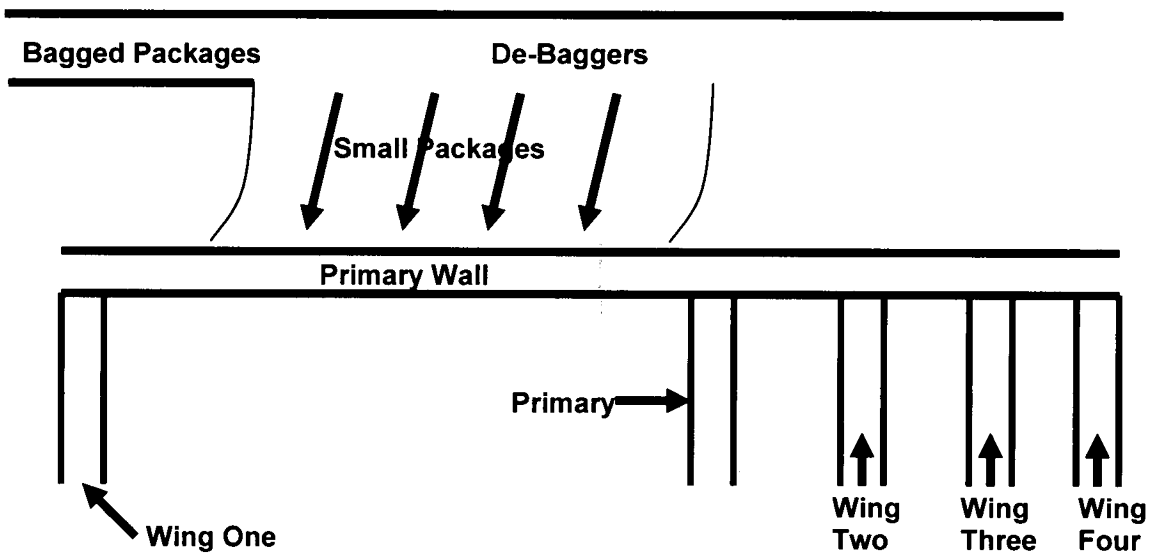
Hubs in general are a cost for UPS. The many expenses include the general necessities for a building such as electricity which powers air, light, the numerous conveyor belt systems, gas for the trucks, and salaries to the many employees which do everything from cleaning the building, to sorting packages, to top the managers. The Dallas ground hub is one of the oldest in Texas, therefore its equipments is relatively old and is not comparable with newer hubs such as the one located in Mesquite, Texas. Due to this, one of the main constraints of this project was not to purchase new multi-million dollar equipment, but to utilize the tools the hub already had.

SECTION 2 – PROJECT DESCRIPTION

2.1 – Current Process

United Parcel Service currently has 1,748 facilities in the United States which include air and ground hubs. Within each ground hub packages are first sorted into big and small packages. In order for a package to qualify as a small it must meet the following criteria: weigh less than eight pounds, not be larger than 16"x 16"x 16", must fit into a small sorting unit, and must not be a hazardous material. The small packages, or smalls as they are referred to in industry, arrive in a larger bag which contains eleven to twelve smalls. The smalls are then placed on a conveyer belt which routs the packages to the small sort area. At this point de-baggers which are standing on the second level of the facility debag and send the smalls down a slide to the primary wall where sorters are stationed to sort the packages yet again onto one of the four conveyor belts which rout them to one of the four wings.

Figure 1 – Small Sort Process



2.2 The Wings

The Small Sort Area is broken into four sub-areas or wings. Wing one contains three 6 x 3 bins where two sorters are stationed at, while wings two, three, and four each contain four 6 x 3 bins with two sorters. Each bin contains eighteen destinations which currently do not comply with any organization. Figure 2 displays UPS's current bin scheme for wing one. UPS will not allow the release of the destination locations, therefore the destination numbers which correlate to the destination locations are placed in the bin scheme. Figure 2 is also color coded in terms of the percentage of each destination to the total small sort volume. The red signifies the highest percentage to total volume followed by yellow, green, blue, and finally purple which signifies the lowest percentage of volume which the small sort receives.

Figure 2 – UPS Current Wing One Bin Scheme

7601	7522	7521
7540	7522	7521
799	7523	7524
799	7526	7525
799	7529	7527
7502	7528	7527

7620	2929	7960
7620	2929	6819
7620	5039	5039
799	7649	6819
799	7649	799
7619	7649	799

7601	7522	7521
7540	7522	7521
799	7523	7524
799	7526	7525
799	7528	7527
7502	7528	7527

2.3 – Problem

The Dallas UPS Hub has a distinct schedule that must be followed every night in order to be part of the company. As stated before, UPS Hubs are nothing more than a cost for the company. With that being said, UPS constrained us quite a bit in our implementation. We were first not permitted to make any machinery addition of any kind to the small sorting process. We were also restricted from motivating, reprimanding, or aiding in any employee during our process. With this being said, we assume that the employees in the small sort section are working to optimal capacity. Also, UPS made it very clear that whatever our process of optimization, we must abide by all safety precautions. UPS is a company that stands very firmly on the safety of its employees and visitors. UPS also needs the different sections of the hub (twilight big packages, day big packages, twilight small packages, etc.) to be unique of one another. When all these constraints are brought together it actually eases the optimization job. With all the constraints stated, UPS ultimately expects us to optimize the small sorting process in such a way that there is a minimal cost for the hub, including our implementation.

SECTION 3 – PROBLEM ANAYLISIS AND APPROACH

3.1 – Methods

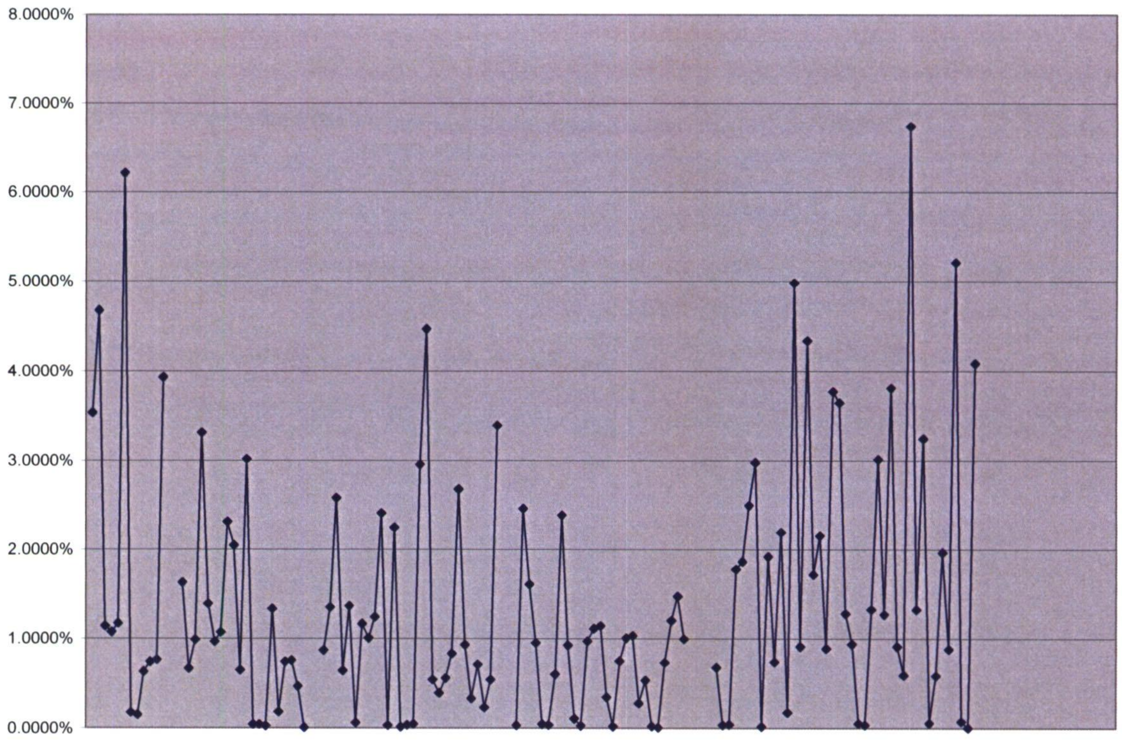
The small sort problem could be solved by taking two different approaches. The whole method would look at the small sort system as a whole, and the wing method would treat each wing as a different problem. Both approaches had benefits and drawbacks, and for both approaches we used the new bin scheme we designed.

3.1.1 – Whole Method

The whole method approach would look at the small sort system as a whole and assign destination locations based on the hierarchy of our bin scheme. Using this bin scheme there would be fifty-eight optimal positions, thirty-two second optimal positions, fifty-four third optimal positions, forty-two fourth optimal positions, and eighty-four least optimal positions. The location of each destination position would be determined by the percentage of each destination to total volume percentage for the small sort as shown in Figure 3. This would then be equally balanced to each of the four wings to prevent one wing from having all large volumes and another from having all small volumes.

If the whole method were to be applied, there would be a higher learning curve for employees and there would be more employee movement. Employees who have become accustomed to their wing and destinations would in turn be forced to learn all new destinations and may have to change wings.

Figure 3 – Percent to Total Small Sort Volume



3.1.2 – Wing Method

The wing method approach would divide the small sort problem into four smaller problems. The first wing, wing one, contained three bins with two sorters. Wings two, three, and four all contained four bins with two sorters stationed at each wing. Taking this into consideration, this method would look at each wing individually and take the percent of each destination to total small sort volume which would then be applied to our bin scheme.

The first item to be considered for the wing method is that each wing is different and therefore contains different percentages to total small sort volume. If each wing is taken as a separate problem it would not be as difficult for each employee to learn a new scheme since it would be the same destinations simply placed in a different location therefore keeping the employees in their current wing. With this in mind, a low percentage in a wing could be a high percentage in another as is the case with wings one and four. Refer to Figures 4 and 5.

Figure 4 – Wing One Percent to Total Volume

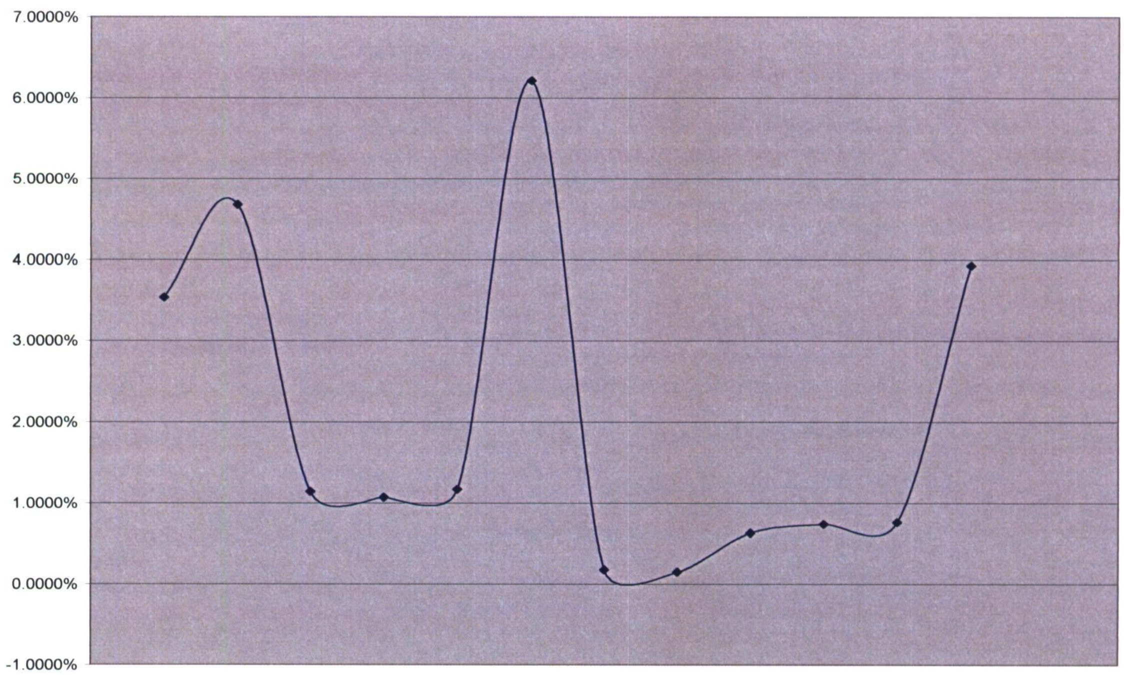
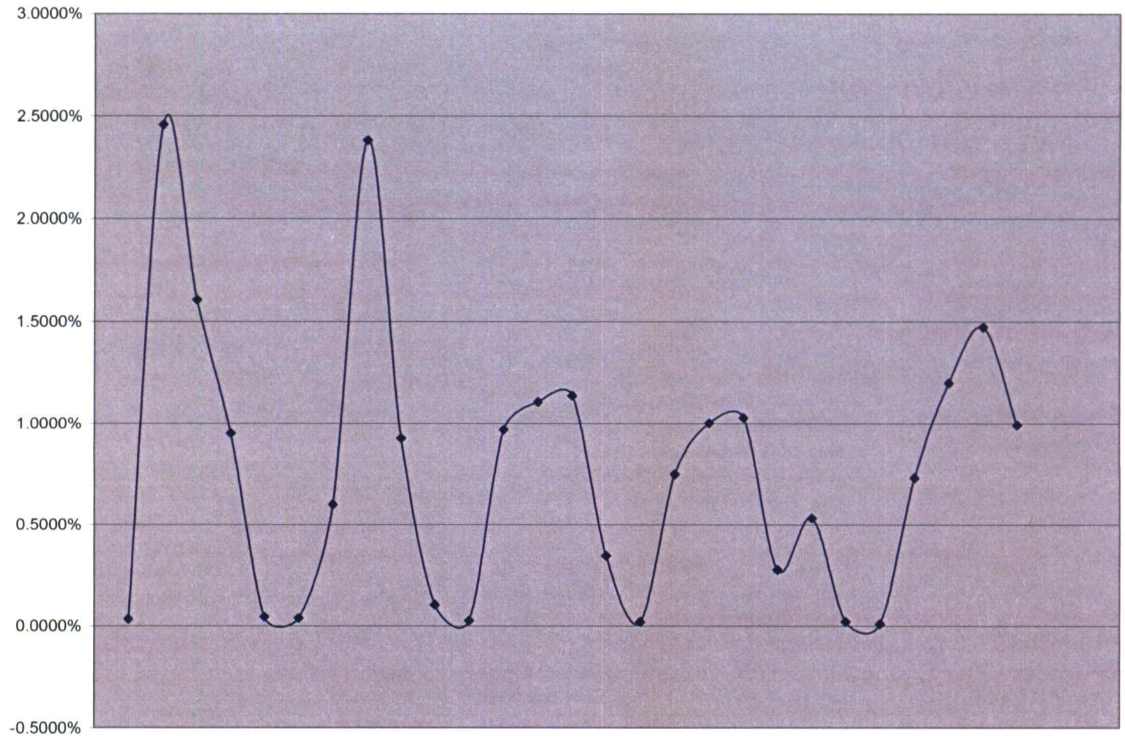


Figure 5 – Wing Four Percent to Total Volume



3.2 – Approach

3.2.1 – Time Measurement Units

The brilliant engineers at UPS came up with an extraordinary tool called the time measurement unit or TMU. Time Measurement Units measure energy, effort, and time consumption. For instance a person carrying a cell phone across a room would have a lower TMU than a person carrying a computer. Similarly, a person placing the cell phone directly in front of him would have a lower TMU than if that person were to place the same cell phone upon a high shelf. Combining this knowledge with the bin scheme, UPS engineers developed the following hierarchy of TMUs which worked in an inside to outside method. A low TMU was assigned to a destination cube which was located at waist height and higher TMUs were assigned to those destination cubes which were located higher and on a diagonal. Figure 6 is an example of a time measurement unit chart for a bin containing seven rows and nine columns.

Figure 6 – Time Measurement Unit Chart

FRONT SORT

Row	8	6	4	2	SECTOR 1	3	5	7	9
1	143.8	71.7	53.8	50.5	50.5	53.8	71.7	143.8	143.8
2	110.2	60.6	50.5	50.5	50.5	50.5	60.6	110.2	143.8
3	71.7	60.6	50.5	40.8	40.8	50.5	60.6	71.7	143.8
4	64.5	54.4	40.8	40.8	40.8	40.8	54.4	64.5	143.8
5	64.5	54.4	40.8	32.0	32.0	40.8	54.4	64.5	143.8
6	64.5	54.4	40.8	32.0	32.0	40.8	54.4	64.5	143.8
7	64.5	54.4	40.8	32.0	32.0	40.8	54.4	64.5	143.8

SORT POSITION

3.2.2 – Formulation of New Bin Scheme

When formulating the new bin scheme, many aspects were taken into consideration. Combining the knowledge of the TMUs, our own tests, and the fact that most of the employees who work in the small sort area are petite women around the height of five feet and two inches, we developed our own bin scheme as shown in Figures 7 and 8. As mentioned in section 3.1.2 there are two types of bin schemes in the small sort area. Wing one contains three bins with two sorters, while wings two, three, and four contain four bins with two sorters each. According to our new hierarchy, the destinations which contained the highest percentage to total small sort volume were placed in the optimal position highlighted in red as shown in Figures 7 and 8. The optimality of the remaining destinations was placed in yellow, green, blue, and purple cubes symbolizing the highest to lowest volume percentages respectively.

Figure 7 – New Bin Scheme Wing One

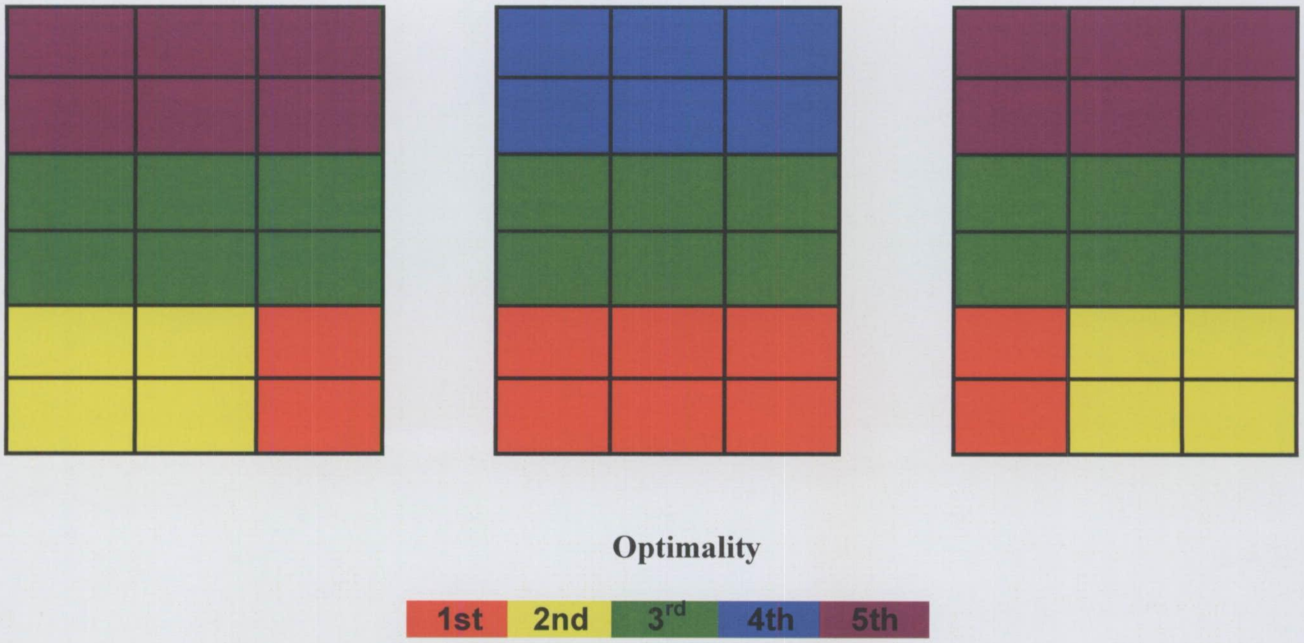
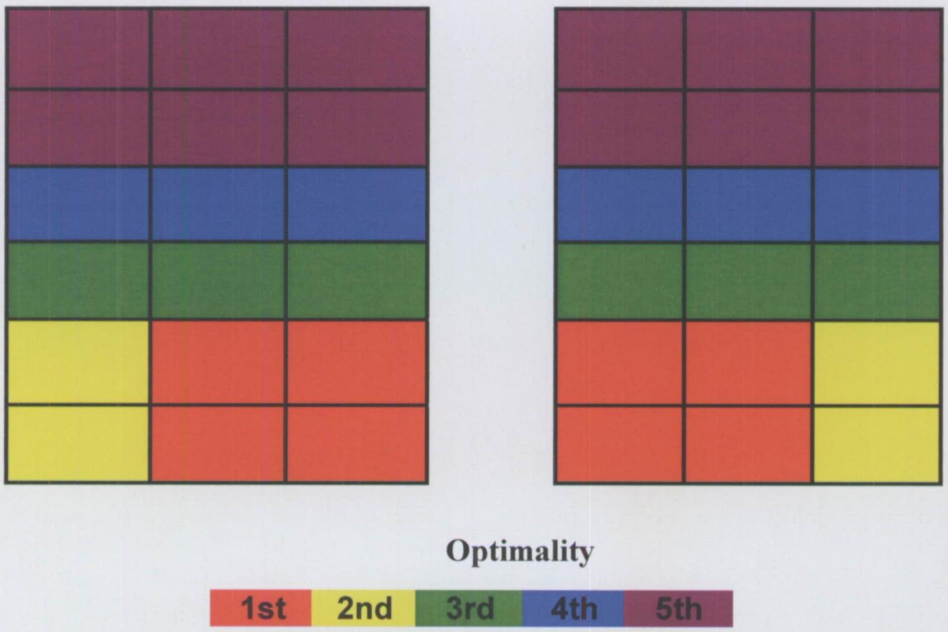


Figure 8 – New Bin Scheme Wings Two, Three, or Four



SECTION 4 – THE SOLUTION

4.1 – Wing Method

The wing method proved to be the best approach to the small sort problem. This method would lower the employee learning curve and not cause employees to move locations. It would much easier for each employee to learn the new scheme while utilizing the knowledge he/she already had.

4.2 – Solution

UPS provided one week's average of total small sort packages per destination. Next Microsoft Excel was used to organize the data by wing and into percentage to total small sort volume. A ranking of each destination was assigned based on the percentage to total volume taking into consideration the fact that destination locations could not be split. Finally the destinations were assigned destination cubes based on the ranking and our new bin scheme as explained in section 3.2.2.

4.3 – New Bin Scheme

Since UPS will not allow the release of actual destination locations the destination numbers have been placed in the destinations cubes to signify the new scheme. The top number is the new destination location and the bottom number is the percentage to total small sort volume for each destination. This is much more efficient than UPS's current method as discussed in Section 2.2 and in Figure 2. Figures 9, 10, 11, and 12 show the proposed bin scheme for wings one, two, three, and four respectively. Recall that wing one contains three bins and two sorters, while the remaining contain four bins or two sets of each bin scheme with one employee at each set.

Figure 9 – Proposed Wing One

7601 0.1176	7540 0.1542	7620 0.6208
7649 0.1476	7502 0.6290	7590 0.7381
7619 3.9251	7619 3.9251	2929 1.1363
7619 3.9251	7619 3.9251	799 4.6731
7529 6.2089	7529 6.2089	7529 6.2089
7529T 0.1737	7529 6.2089	7529 6.2089

7600 0.7605	7600 0.7605	7600 0.7605
5039 1.0681	5039 1.0681	5039 1.0681
2929 1.1363	2929 1.1363	2929 1.1363
799 4.6731	799 4.6731	799 4.6731
7529 6.2089	7529 6.2089	7529 6.2089
7529 6.2089	7529 6.2089	7529 6.2089

7620 0.6208	7960 0.3358	6819 0.1288
7590 0.7381	7502 0.6290	7649 0.1476
2929 1.1363	7619 3.9251	7619 3.9251
799 4.6731	7619 3.9251	7619 3.9251
7529 6.2089	7529 6.2089	7529 6.2089
7529 6.2089	7529 6.2089	7529T 0.1737

Figure 10 – Proposed Wing Two

7980 0.0062	7752 0.0397	8719S 0.0583
7756 0.5546	7730 0.6463	7790 0.4640
6309S 1.0669	7780 0.7505	7759 1.3311
1329 1.6239	8719T 1.9613	8719T 1.9613
7709S 2.0419	7749 3.0133	6059 3.3073
7709P 2.3062	7749 3.0133	6059 3.3073

8749T 0.0583	7760 0.1799	7753 0.0248
5549 0.9850	4429 0.6637	7750 0.0409
7759 1.3311	7770 0.7381	1329 1.6239
8719T 1.9613	8719T 1.9613	1329 1.6239
6059 3.3073	7749 3.0133	7709S 2.0419
6059 3.3073	7749 3.0133	7709P 2.3062

Figure 11 – Proposed Wing Three

7430 0.0136	5719 0.0583	7800 0.3908
7480 0.0447	3229 0.6389	7829N 0.7059
7419 2.2429	6729 1.1611	7319A 1.0011
7976 2.6721	7319P 2.4042	7319P 2.4042
7519N 2.9488	7879 3.3854	7879 3.3854
7829P 2.6721	7879 3.3854	7879 3.3854

7850 0.3300	7852 0.2295	7370 0.0285
7851 0.7059	7821 0.5558	7860 0.5396
7319A 1.0011	7319N 1.2368	7976 0.5409
7319P 2.4042	7319P 2.4042	7419 2.2429
7879 3.3854	7879 3.3854	7519N 2.9488
7879 3.3854	7879 3.3854	7829P 2.6721

Figure 12 – Proposed Wing Four

7901 0.0074	3790 0.0323	7120 0.0434
7270 0.1042	7580 0.3449	7180 0.5979
7652 1.0011	7639 0.7468	7540 0.9664
7999 1.47139	7560 1.1066	7940 0.9664
7999 1.47139	7229N 2.3806	3849 2.4563
7119N 1.604	7229N 2.3806	3849 2.4563

7290 0.0248	7631 0.0186	7130 0.0360
7939 0.7294	7690 0.5310	7680 0.2766
7119P 0.7294	7229P 0.9230	7229P 0.9230
7570 1.1376	9729 0.9912	7999 1.4713
3849 2.4563	7229N 2.3806	7119N 1.604
3849 2.4563	7229N 2.3806	7119N 1.604

SECTION 5 - SAVINGS

5.1 – Percent to Total Volume Savings

The new bin scheme combines the TMUs with the percentage of each destination to total volume in each wing. The new bin scheme was laid on top of UPS's current bin scheme and the difference of the percentages was taken to see the savings. Recall that there are five positions in which a destination may be placed within the bin scheme. The difference in the most optimal position of UPS's bin scheme to our bin scheme should be a large percentage, while the difference in the least optimal position should be a very small and usually negative percentage. The percentage differences for the second, third, and fourth optimal positions should ideally descend, however they should be relativity close to each other and their outcomes are not as important as the most and least optimal position. The new bin scheme saved the optimal position in wing one 21.13% to total volume, and it reduced the least optimal position down by 45.21%. Similar improvements were made in the remaining wings such as wing two where the optimal position saved 18.97% total volume and reduced the least optimal position by 9.83%. The optimal position saved 13.87% to total volume in wing three, while reducing the least optimal by 8.97%, and the fourth wing was saved 15.46% of the most optimal and reduced the least optimal by 7.70%. Figures 13, 14, 15, and 16 are comparison tables for UPS's and our bin scheme for wings one, two, three, and four respectively.

5.2 – Monetary Savings

When the small sorting process does not operate at full efficiency there is a high cost involved. When the sorting process is backed up, the employees must often stay an average of about forty five minutes longer than their shift. When the average employee's wage is about ten dollars per hour, at about 20-25 employees, it is clear that the extra forty five minutes can be extremely costly to the company.

Our goal is to eliminate this back up of packages so that the small sorting process can be at an optimum. At a forty five minute delay of the small sorting process the extra cost is about $150.00 to $187.50. Usually this happens at busier days of the week, which is Mondays, Tuesdays, Wednesdays, and Thursdays. When this extra day cost is spread out for the four busy days of the week the extra cost becomes $600.00 to $750.00. It is very clear that eliminating the extra forty five minutes from the small sorting process can save the Dallas Hub a great deal of money in the long run.

Figure 13 – Wing One

Our bin scheme

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
6.2089	6.2089	3.9251	0.7605	0.1176
6.2089	6.2089	3.9251	0.7605	0.1476
6.2089	6.2089	3.9251	0.7605	0.1542
6.2089	6.2089	3.9251	1.0681	0.629
6.2089	6.2089	3.9251	1.0681	0.6208
6.2089	6.2089	3.9251	1.0681	0.7381
6.2089	0.1737	3.9251		0.6208
6.2089	0.1737	3.9251		0.7381
6.2089		4.6731		0.3358
6.2089		4.6731		0.629
		4.6731		0.1288
		4.6731		0.1476
		4.6731		
		1.1363		
		1.1363		
		1.1363		
		1.1363		
		1.1363		
total 62.089	total 37.6008	total 60.4478	total 5.4858	total 5.0074

Original bin scheme

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
6.2089	6.2089	4.6731	0.6208	6.2089
6.2089	6.2089	4.6731	0.6208	6.2089
4.6731	6.2089	4.6731	1.1363	6.2089
4.6731	6.2089	4.6731	1.1363	6.2089
4.6731	6.2089	4.6731	0.3358	6.2089
4.6731	6.2089	6.2089	0.1288	6.2089
0.629	4.6731	6.2089		6.2089
0.1476	0.629	6.2089		6.2089
0.1476		6.2089		0.1176
3.9251		6.2089		0.1176
		6.2089		0.1542
		6.2089		0.1542
		6.2089		
		0.6208		
		0.1476		
		0.1288		
		1.0681		
		1.0681		
total 35.9595	total 42.5555	total 76.0701	total 3.9788	total 50.2148

difference

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
26.1295	-4.9547	-15.6223	1.507	-45.2074

Figure 14 – Wing Two

Our bin scheme

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
3.3073	2.0419	1.9613	1.3311	0.0583
3.3073	2.0419	1.9613	1.3311	0.0583
3.3073	2.3062	1.9613	0.7381	0.464
3.3073	2.3062	1.9613	0.7505	0.6463
3.0133	total	1.6239	1.0669	0.0397
3.0133	8.6962	1.6239	1.6239	0.0062
3.0133		total	total	0.5546
3.0133		11.093	6.8416	0.895
total				0.1799
25.2824				0.6637
				0.0248
				0.0409
				total
				3.6317

Original bin scheme

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
0.0409	0.0397	3.3073	2.3062	0.7505
1.3857	0.0397	3.3073	2.3062	1.3311
1.3857	0.0397	3.3073	2.3062	1.9613
0.7381	0.0397	0.985	3.0133	1.3311
0.985	total	0.5546	3.0133	0.0583
0.464	0.1588	0.1799	3.0133	1.6239
0.6637		total	total	1.0669
0.6463		11.6414	15.9585	1.0669
total				1.0669
6.3094				1.0669
				1.0669
				1.0669
				13.4576

difference

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
18.973	8.5374	-0.5484	-9.1169	-9.8259

Figure 15 – Wing Three

Our bin scheme

1st Most	Optimal	2nd Most	Optimal		3rd Most Optimal		4th Most Optimal		5th Most Optimal
	3.3854		2.9488		2.6721		1.0011		0.0136
	3.3854		2.9488		2.4042		1.0011		0.0447
	3.3854		2.6721		2.4042		1.1611		0.0583
	3.3854		2.6721		2.4042		1.2368		0.6389
	3.3854	total			2.4042		2.2429		0.3908
	3.3854		11.2418		2.2429		0.5409		0.7059
	3.3854			total		total			0.33
	3.3854				14.5318		7.1839		0.7059
total									0.2295
	27.0832								0.5558
									0.0285
									0.5396
								total	
									4.2415

Original bin sceme

1st Most	Optimal	2nd Most	Optimal		3rd Most Optimal		4th Most Optimal		5th Most Optimal
	1.9179		0.8857		1.3199		1.3472		0.2295
	1.9179		0.8857		1.3199		1.3472		0.5558
	0.6749		0.0447		1.1611		0.8671		0.7059
	0.6749		7.9488		2.2429		2.4042		0.3908
	0.0285	total			2.2429		2.4042		0.33
	0.0335		9.7649		1.7752		2.4042		0.6389
	0.0136			total		total			0.5396
	7.9488				10.0619		10.7741		1.2368
total									0.9279
	13.21								2.5754
									2.6721
									2.4042
								total	
									13.2069

difference

1st Most	Optimal	2nd Most	Optimal		3rd Most Optimal		4th Most Optimal		5th Most Optimal
	13.8732		1.4769		4.4699		-3.5902		-8.9654

Figure 16 – Wing Four

Our bin scheme

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
2.3806	1.47139	1.47139	1.0011	0.0074
2.3806	1.604	1.1066	0.7468	0.1042
2.3806	1.604	0.9664	0.9664	0.0323
2.3806	1.604	1.1376	0.7294	0.3449
2.4563	total	0.9912	0.923	0.0434
2.4563	6.28339	1.4713	0.923	0.5979
2.4563		total	total	0.0248
2.4563		7.14449	5.2897	0.7294
total				0.0186
19.3476				0.531
				0.036
				0.2766
				total
				2.7465

Original bin scheme

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
1.1376	0.2766	0.7359	1.1066	0.949
0.0323	0.3449	0.7359	0.7468	0.949
0.9912	0.9093	0.7359	0.7381	0.0434
0.9912	0.5409	7.4713	2.3806	0.5979
0.1042	total	1.0284	2.3806	0.036
0.0186	2.0717	2.4563	0.923	0.7294
0.0248		total	total	1.1996
0.5905		13.1637	8.2757	1.604
total				1.1996
3.8904				1.604
				0.531
				1.0011
				total
				10.444

difference

1st Most Optimal	2nd Most Optimal	3rd Most Optimal	4th Most Optimal	5th Most Optimal
15.4572	4.21169	-6.01921	-2.986	-7.6975

CONCLUSION

United Parcel Service's Dallas ground hub currently uses inefficient sorting methods in their small sort. UPS engineers developed time measurement units which measure the time, energy, and effort placed into performing a certain task. Time measurement units were taken into consideration, along with the fact that most sorters in the small sort are petite women whose heights do not exceed five feet and two inches. This was combined with the percentage to total volume of the small sort area to formulate a new bin scheme. The new bin scheme ranked each destination into one of five optimal locations according to the percentage to the total small sort volume. The destinations were then reassigned a new location within the bin scheme. The difference in UPS's original bin scheme from that of the new bin scheme had to produce a high percentage. The difference in the least optimal position would result in a low or negative percent. The remaining positions produced percentages which were relatively close. The new bin scheme saved an average of 18.61% in the most optimal position and reduced the least optimal position by an average of 17.93%.