THE BART-SFO EXTENSION
Early Findings and Some Tentative Conclusions

NEXTOR RESEARCH REPORT
NR-2005-002

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Submission date: July 30, 2004
Word Count: 3,809 + (11*250) = 6,559 words

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AVIATION OPERATIONS RESEARCH

ABSTRACT
In this paper, some data and analysis is presented about the BART-SFO (Bay Area Rapid Transit- San Francisco International Airport) extension. First, the market share of BART to SFO will be discussed along with a comparison among domestic and international airport rail services. This is then followed by a discussion of the percentage share of geographical area using the service, total monthly ridership, and enplanement/deplanement values at SFO. Preliminary results show that BART captures more of the mode share for persons leaving the airport (egress) as opposed to going to the airport (access). Ridership data based on geographical areas indicates that the Downtown San Francisco area dominates with ridership shares ranging from 39.3% to 55.3%. The total monthly ridership for those to and from SFO dropped to levels in December 2003 and April 2004 below its opening in July 2003. This could indicate that BART had higher values in its first month because it just had opened and patrons were curious to try it. Although it is still early at this time to make any decisive conclusions about the success of the BART-SFO extension, preliminary results indicate that mode share is hovers around the 6% to 7 % range. This is actually a relatively good share and can be considered as somewhat successful when compared to other airport rail services in the U.S. However, in comparison to European and Asian services, this value is actually very low.

INTRODUCTION

The BART-SFO extension was advocated by many because of the benefits that it was projected to bring. This extension was expected to improve the region's livability by decreasing congestion on highways and therefore improving the air quality, eliminating about 82 tons of hydrocarbons per year. It was also estimated that this extension would sustain about 12,000 jobs and provide increased worker mobility, giving workers living in Milbrae, San Bruno, and South San Francisco an alternative mode to the car to get to work. Also, this improved access system was seen as a catalyst for local development. Symbolically, the extension was seen as a way for San Francisco to keep pace with the world. Many major cities around the world including Paris, London, Frankfurt, Osaka, Hong Kong, Vienna, Moscow, and Osaka as well as U.S. cities such as Washington, Atlanta, Boston, and most recently New York have rail access to their airports (1). Now San Francisco, a major city in its own right, joins the "club" by providing rail access to its airport.

Since the BART-SFO service has only been open for eleven months it is still too early to make any definitive conclusions about its effect on the Bay area. It would require at least a few years of rideship data and an air passenger ground access survey to assess its impacts on travel behavior and any economic impacts on the region. In this paper, ridership data is used to determine BART's initial mode share to SFO and to compare it to other rail services. The data is also used to determine the geographical areas that capture most of this share.

MARKET SHARE

From the BART ridership and the SFO enplaned/deplaned passenger data discussed later in the report, a BART mode share was determined (Figure 1). Note that these percentages are labeled "To SFO" and "From SFO" as opposed to "% of enplaned passengers" and "% of deplaned passengers". This is because the BART ridership data does not differentiate between riders who are passengers of SFO, airport employees, or other riders (i.e. family and friends) going to the airport. Therefore, caution must be taken not to mistake these values as the percent of air passengers whose mode choice was BART.

These values indicate that BART captures more of the mode share for persons leaving the airport. This is consistent with the fact that in many cases during this time period, deplanement values are higher than enplanement values for SFO as will be discussed in a later section. The difference in mode share can also be due to air passengers choosing a different egress mode. Since employees would likely use the same mode to get to and from work, the results lead us to believe that either the passengers making the return trip are more likely to use BART on the return portion of the trip, passengers visiting the Bay Area are more likely to use BART, or both of the previous explanations.

COMPARISON AMONG DOMESTIC AIRPORT RAIL SERVICES

To be able to understand how the BART-SFO extension is fairing, it is a good idea to compare it to other airports providing rail access. In the1999 *Rail's Share of Airport Access Examining the Data* publication, Newmark presented rail mode shares for eight airports in the U.S. Table 1 is an excerpt from a table in his paper with the SFO value inserted.

It is important to realize that one cannot directly compare these percentages with those obtained for SFO without noting some differences. The percentages obtained for SFO include air passengers, airport employees, and "other" riders and are calculated from BART ridership data. Newmark however, uses different sources such as historical survey data and interviews with

several airport, transit, and MPO officials to estimate the air passenger and airport employee rail mode shares. In his paper, he discusses the difficulty in determining the airport employee and "other" rail mode shares citing the fact that little research and surveys have been conducted for these groups. This is the case for SFO; since the opening of the BART in July 2003, no Bay Area ground access surveys or air passenger surveys have been done. This makes it almost impossible to estimate distinct rail mode shares for each of the groups.

While the values in Figure 1 represented the most recent rail mode shares for both access and egress, Table 2 presents only the percentage for access only from 1992 data. It also differs in that it does not differentiate between the possible groups of airport rail riders. These values are consistent with Newmark's findings (1999) that rail mode shares are low for airports in the U.S. Taking into account the differences in the calculation procedure mentioned above, the values in 1992 and 1999 indicate that rail ridership percentages had been hovering around the same values in that seven-year period. Comparing the SFO percentage (6.33%) to the other U.S. rail mode shares, it looks like SFO is actually doing fairly well considering that the rail extension has been open for less than a year.

It would be interesting to know what other modes' market shares BART took. However, since there have not been any ground access surveys done after the BART extension to SFO opened, this question cannot be answered at this point.

COMPARISON AMONG INTERNATIONAL AIRPORT RAIL SERVICES

In Chapter 5 of TCRP Report 62, Coogan looked at 14 successful rail services. Not surprisingly, none were in the U.S. The characteristics of the rail services and the airports were studied in hopes of trying to understand what makes an airport rail service successful and how the European and Asian strategies can be implemented in the U.S. Table 3 is taken from the TCRP report and it ranks the rail system in terms of rail mode share.

An important thing that Coogan pointed out was that ranking is not exactly correlated to distance or to the size of the airport, therefore these characteristics alone should not be used to forecast market shares for rail (2). This is evident from Table 4 where Oslo has a farther distance, but still captures more share than those with a shorter distance. It is interesting to note that Narita and Geneva capture almost the same share even though they differ significantly in airport distance. As for airport size, the two largest airports, Frankfurt International and Heathrow are in the middle in terms of ranking while the smaller airports vary in ranking (3).

The TCRP report identifies four important elements in an airport rail system:

1. Service to downtown and the metropolitan area;
2. Service to national destinations beyond the metropolitan area;
3. Quality of the rail connection at the airport, or the airport-railway interface; and
4. Baggage-handling strategies and off-site facilities (4).

In the following paragraphs we consider how these elements fit in the SFO-BART case. First, it is important to differentiate between dedicated and shared rail services. Dedicated rail service means that there are special vehicles designed to meet the needs of the airline passengers. In the past, London /Gatwick and Tokyo/Narita were the only dedicated services. However, since 1998 more airports such as Oslo, London/Heathrow, Milan, Hong Kong, and Stockholm have opened new dedicated services (5). More important for this study however, is to look at the shared services where airline passengers use the same vehicle as other passengers. This is because the SFO-BART is a shared service.

One characteristic of most shared rail services is that it has many distribution points, but has relatively slow line-haul travel speeds. In the TCRP report, Coogan discusses how Munich can be used as an example of a local strategy for low-speed shared service. With the new Munich S-Bach system, the headway for the airport is ten minutes. Also, it provides access to nine downtown stations and ten local rail lines (6). SFO can be somewhat compared to the Munich S-Bach system. SFO can be reached by BART from any of the other 41 BART stations and using any of the five lines. However, only two lines (Pittsburg /Bay Point and Richmond/Daly City) offer direct services. There is a transfer required if using any of the other lines (Daly City/Fremont, Fremont/Richmond, and Dublin/Pleasanton). The headway for BART-SFO is fifteen minutes and it has an average speed of 33 mi/hr. Thus, BART provides a somewhat low speed, but has many stops.

Taking the London Heathrow Airport as a case study, Coogan looked at express service versus multi-stop service. He came to the conclusion that "even with significant differences in line-haul times, for many air passengers the modal decision may be less driven by in-vehicle travel times than by the convenience of the trip" (7). This was also his conclusion when he looked at the Hong Kong MTRC to study fast services versus slower, direct service. Another important thing worth noting is that while "shared services make the air traveler endure whatever level of overcrowding exists on the rail vehicle during rush hour"; it has the advantage of having many stops (8). The dedicated service however provides guaranteed quality of service on its segment, but leaves "the user with the need to find adequate distribution from the rail terminal" (9).

Examining the line-haul travel times for the rail connections in the study resulted in important implications for the U.S. practitioner. First, there is a difference in travel-time conditions. Four of the airports in the study have service that is twice as fast as by automobile. This relative advantage would be almost impossible to attain in the U.S. because of the extent of the fast highway connections. Second, it is the comparative travel time on a door-to door basis that influences choice rather than relative travel times to downtown.

In terms of distance, SFO is about 14.7 miles away from Civic Center (the first stop in downtown San Francisco when leaving from SFO) and 16 miles from Embarcadero (the last stop in downtown San Francisco) and has an average of about 15.39 miles to the downtown stations. This is similar to the Charles de Gaulle and the London Heathrow Airports, which are about 15 miles from downtown. While these airports capture a 20 and 25 percent rail mode share, respectively, SFO only captures 6.33 percent. Clearly, distance alone is not a good indicator of mode share.

The level of service of the rail connection at the airport is also important. All BART stations are outfitted with elevators, making it easier to carry baggage to the boarding points. However, only the SFO station is equipped with baggage carts. It is noted in the TCRP report that a characteristic of most of the successful airports is that it has rail service to all air terminals. This is difficult to do at U.S. airports and most airports in the U.S. have a people mover to link the rail to the terminal. BART stops at the International Terminal at SFO therefore providing easy access for international travelers. However, more effort is required for domestic travelers, as they have to go to the top floor and take AirBart to connect them to the Domestic Terminal. This is not considered a very big hassle because of the seamlessness of the transfer. The fact that BART only has one stop at the airport is actually an advantage. According to the report, "most of the airports with the highest mode shares to rail are characterized by direct rail connections to a single, centralized point of transfer to a compact landside terminal" (10). Thus, the important

result from the TCRP study is that good airport connections are necessary to capture a high mode share, but they are not sufficient.

Baggage-handling strategies are also very important, but this remains a controversial topic in airport ground access. The study indicates that although an off-site baggage strategy does positively influence rail mode share, a high share can still be achieved without such a strategy (11). Considering the long history of off-airport terminals, this topic will not be covered in this report.

Overall, the major conclusion from the Chapter 5 of the TCRP report is that there is no single solution or strategy that leads to a successful rail system. The success depends in identifying and meeting the demands of the submarkets.

PROCEDURE

The data collection and compilation procedure will be discussed, followed by the presentation and analysis of various results. The tables and figures presented here are based on data compiled from ridership data that came directly from BART and from SFO. The BART data came in Weekday, Saturday, and Sunday O-D (Origin –Destination) matrices (i.e. riders exiting and entering from each BART station). The SFO row and column data for each case in each month were extracted; these correspond to the number of riders exiting and entering at the SFO station, respectively. To be able to conduct an analysis, the data had to be grouped. After rejecting a grouping based on the absolute distance of each station to the SFO station and another based on the rail line that each station belonged to, a grouping based on geographical location was chosen. Thus, the stations were divided into 14 areas. The total monthly month ridership was then determined. The number of enplaned and deplaned passengers at SFO was obtained. Then from the previous two forms of data, the percent of passengers using BART to and from SFO for each of the months were calculated, as was seen in Figure 1.

RIDERSHIP BASED ON GEORGRAPHICAL AREAS

Based on the geographical area classification in Table 4, Figures 2 and 3 representing the January 2004 ridership percentages to and from SFO were plotted. Similar graphs were plotted for the other months, but are not shown here. These figures indicate that Area A (Downtown San Francisco) captures the highest share for those exiting (to SFO) and entering (from SFO). Table 5 gives the three categories that had the highest percentages (share) of BART ridership to and from SFO based on Weekly Average values. Results indicate that Area A (i.e. the stations that were part of the BART-SFO Extension) is doing well in terms of weekday ridership since it has the third and fourth highest share in many cases. It also indicates that Area D (Downtown San Francisco) dominates with shares ranging from 39.3 % to 55.3%. This makes sense since many of the visitors are likely to be staying at hotels that are located downtown.

Although the total number of passengers entering at the SFO Station (i.e. leaving SFO) is greater than that of those exiting (i.e. coming to SFO) in all those month (July 2003-April 2004), downtown San Francisco (Area D) had less of the market share in August and November 2003, and January and April 2004 than that for exiting. However, one should be careful not to misinterpret the difference in percentages to mean that in these months, more people coming from downtown San Francisco are using the BART to get to SFO than those who are going from SFO to downtown San Francisco. This is because although they are a smaller percentage, the total number of passengers is still greater.

TOTAL MONTHLY RIDERSHIP

As mentioned previously, the total monthly ridership values for those exiting and entering at the SFO station were calculated based on the weekly average. Graphical representations of Weekday, Saturday, Sunday, and Weekly Average values were plotted, however only those for Sunday and Weekly Average values are presented in this paper.

These figures (Figures 4 and 5) show that ridership for those to and from SFO dropped to levels in December 2003 and April 2004 below its opening in July 2003. This could indicate that BART had higher values in its first month because it just had opened and patrons were curious to try it. Also worth noting is that the total monthly riders entering at the SFO Station is always higher than those exiting for the corresponding months; the time period average for entering at the SFO station is 13,134 more (as seen in Figure 5). This indicates that more people are using BART on the return portion of the trip, most likely the deplaned passengers.

ENPLANEMENTS/DEPLANEMENTS AT SFO

Figure 6 shows the number of enplaned and deplaned passengers at SFO for the months in the study. Note the differences in the number of enplaned and deplaned passengers from month to month. This difference is due to a combination of several effects. First, air travel has a weekly cyclical pattern. Since the end of the month often occurs in the middle of the week, a person leaving one day and retuning a few days later will be counted as an enplaned passenger in one month and a deplaned passenger in the next month. Second, for longer duration trips such as vacations, persons leave in one month as enplaned passengers and return in the next or even later months. According to Gosling, these effects along with the seasonal fluctuations in air travel interact to produce the monthly imbalance in the number of enplaned and deplaned passengers (unpublished data). This is clearly evident in Figure 6, where in December 2003 (the holiday season) the number of enplaned passengers is higher than the deplaned because people are leaving for vacation. However, in January 2004 the situation is reversed because people are returning home.

RESULTS & DISCCUSSION

Although it is still early at this time to make any decisive conclusions about the success of the BART-SFO extension, preliminary results indicate that mode share hovers around the 6% to 7 % range. Again, this is actually a relatively good share and can be considered as somewhat successful when compared to other airport rail services in the U.S. However, in comparison to European and Asian services, this value is actually very low. But one must remember that the U.S. market is very different from those international markets, therefore it is hard to attain such high mode shares even if similar strategies are used in planning new rail services. For U.S. airports to be able to achieve similar performance, there has to be a major shift in people's attitude towards public transit. Non-U.S. rail services are a success because in those countries, owning a vehicle and driving in general is not as easy or as cheap as in the U.S due to stricter regulations. Also, the areas are more densely populated making it easier to use public transit. Therefore, no matter how great the quality of service of the rail is, there is a need for more demand for public transit to make rail services a success in the U.S.

When Monteiro and Hansen developed an airport choice model for the Bay Area, they predicted that the introduction of the BART-SFO extension would make SFO even more dominant in the Bay Area, that it would be a more popular choice with non-resident travelers rather than residents, and that it would be the "second most likely scheduled mode of

transportation and that the mode that would have the greatest drop in choice probability is drop-off" (12). Currently, the first and last predictions cannot be validated or refuted because there has not been a ground access survey since the opening of the BART-SFO extension. As for the second prediction, the fact that the percent of people using BART as an egress mode is higher than that for access may help validate the fact that non-residents are more responsive to the service. However, it is not possible to state this as a fact without conducting a ground access survey. This study was only based on the first ten months of the BART-SFO service. Further research needs to be done on this topic, but with a longer time frame. Only then will it be possible to really understand and study how the addition of this service has made any changes in people's mode choice.

ACKNOWLEDGEMENTS

The authors would like to thank NEXTOR AT UC BERKELEY and the California Department of Transportation (Caltrans) for providing funding for this research. They would also like to thank the Bay Area Rapid Transit (BART) and San Francisco International Airport (SFO) for providing the necessary data.

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(12) Monteiro, Ana Beatriz, and Mark Hansen. “Improvements to Airport Ground Access and the Behavior of a Multiple Airport System: BART Extension to SFO Airport.” Transportation Research Board 75th Annual Meeting (1996):1-32.

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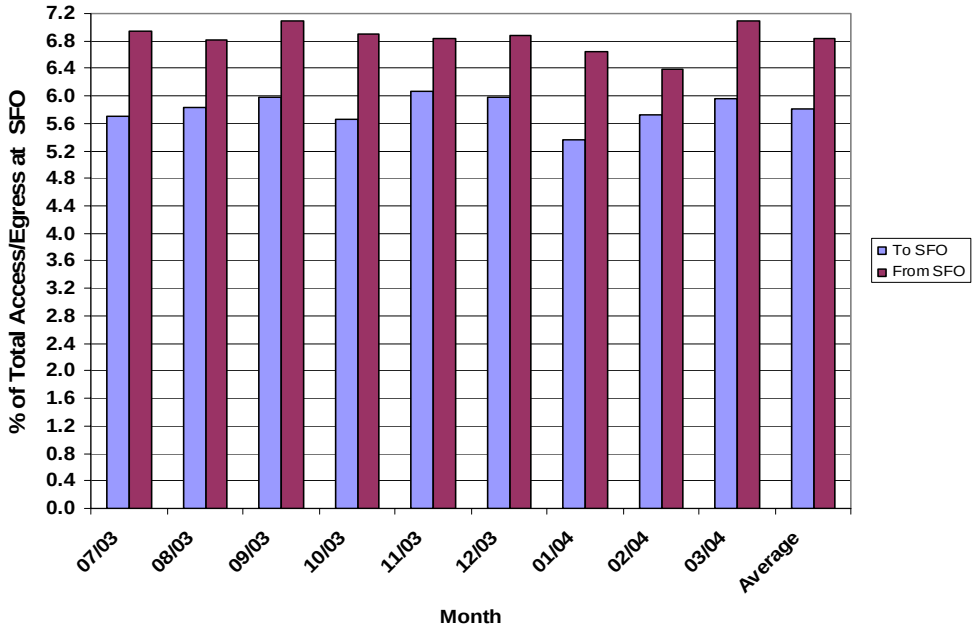

Figure 1 BART Mode Share

Notes: 1) The values are averages of the specific area for each month.

2) *Weekly average values are the averages of the three categories (Weekday, Saturday, and Sunday values).*
3) *The monthly "To SFO" and "From SFO" are based on Weekly average values.*
4) *These values are total percentages (i.e., include air passenger, airport employees, and "others" who use BART to get to and from SFO).*

TABLE 1 U.S. Rail Mode Shares, 1999

Airport	Air Passenger (%)	Airport Employee (%)	Calculated % of Airport Rail Ridership (Composed of Air Passengers)
Atlanta	6.0	N/A	37.3%
Boston	5.7	11.0	42.0%
Chicago (Midway)	8.1	N/A	13.4%
Chicago (ORD)	5.4	14.0	30.7%
Cleveland	3.0	N/A	39.8%
Philadelphia	2.0	N/A	24.0%
St. Louis	5.0	8.0	44.2%
San Francisco (SFO)	6.33**	N/A	N/A
Washington (National)	9.0*	N/A	44.1%

**The rail mode share for air passengers at Washington historically has a higher value. However, Newmark wrote this paper as the air terminal and its connection were being reopened after a lengthy construction process. He therefore admits that the value has since increased.*
***This percent is the average of the access % (5.81) and egress % (6.85).*
Source: Newmark

TABLE 2 BART-SFO, Comparison among U.S. Access Rail Markets 1992

Airport	*Overall Rail Share (%)
Atlanta	9.0
Boston	7.5
Chicago (ORD)	3.7
Cleveland	3.8
New York (JFK)	3.7
Philadelphia	4.4
San Francisco (SFO)	5.8**
Washington (DCA)	15.0

** "Overall Rail Share" is the percentage of passengers who access the airport by rail*

*** 2004 value*

Source: Hanan Kivett

TABLE 3 Ranking of Rail Systems in Terms of Mode Share

Rank in sample	Airport	Rail mode share (%)	Airport distance to CBD (mi)
1	Oslo	43	30
2	Narita	36	42
3	Geneva	35	3
4	Zurich	34	8
5	Munich	31	18
6	Frankfurt	27	6
7	Stansted	27	34
8	Amsterdam	25	9
9	Heathrow	25	15
10	Hong Kong	24	21
11	Gatwick	20	28
12	Charles de Gaulle	20	15
13	Brussels	16	10
14	Orly	14	8

Source: Coogan

TABLE 4 Geographical Areas

Area Code	Name of Area	Stations in Area
A	SFO Extension	San Francisco International Airport, Milbrae, San Bruno, South San Francisco
B	Daly City	Colma, Daly City, Balboa Park
C	Glen Park	Glen Park, 24th St.-Mission, 16th St.-Mission
D	Downtown San Francisco	Civic Center, Powell, Montgomery, Embarcadero
E	Oakland	West Oakland, 12th St. Oakland, 19th St.-Oakland, MacArthur
F	Fruitvale	Lake Merritt, Fruitvale, Coliseum
G	Berkeley	Ashby, Downtown Berkeley, North Berkeley, Rockridge
H	Richmond	Richmond, El Cerrito Plaza, El Cerrito del Norte
I	Bay Fair	San Leandro, Bay Fair, Castro Valley
J	Hayward	Hayward, South Hayward
K	Fremont	Union City, Fremont
L	Pittsburg/Bay Point	Pittsburg/Bay Point, North Concord, Concord
M	Orinda	Orinda, Pleasant Hill, Walnut Creek, Lafayette
N	Dublin/Pleasanton	Dublin/Pleasanton

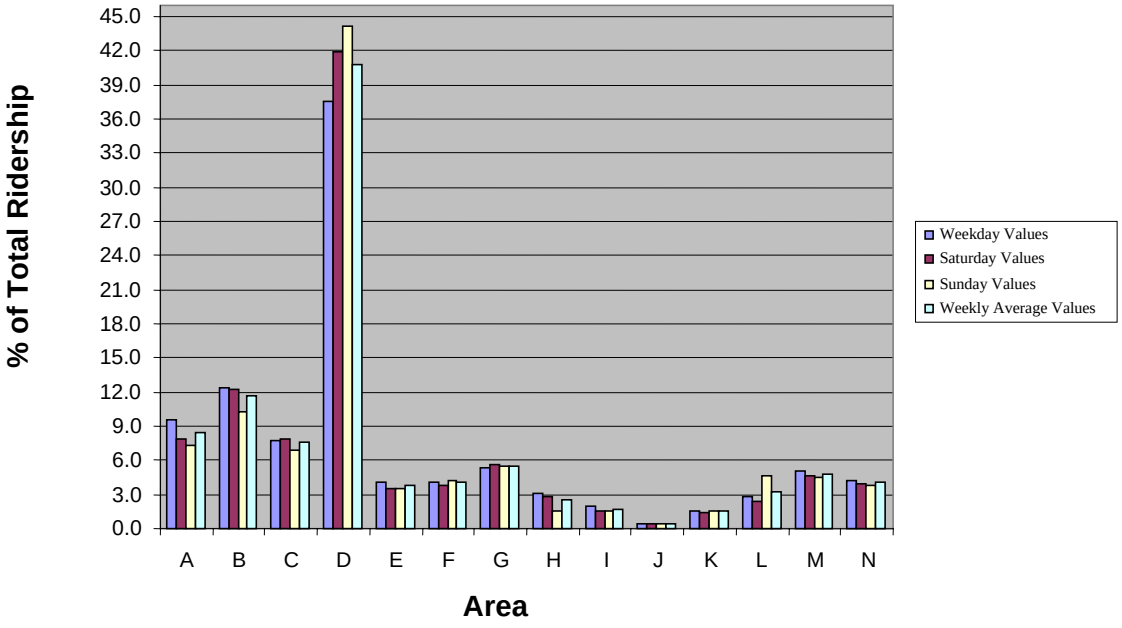

Figure 2 January 04 Ridership to SFO

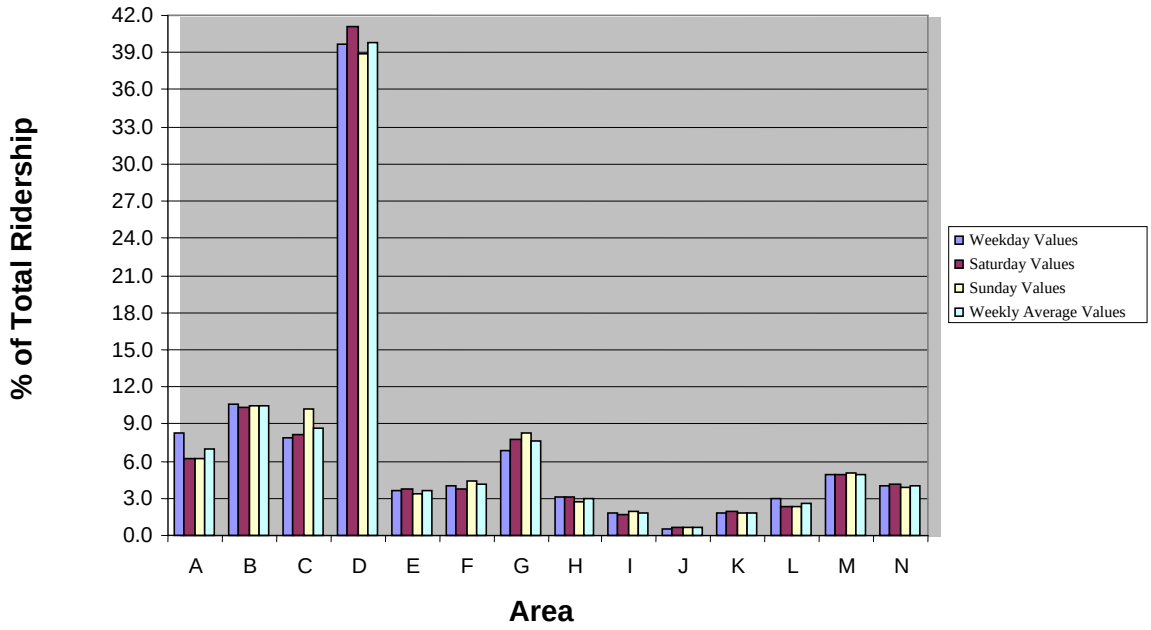

Figure 3 January 04 Ridership from SFO

TABLE 5 Areas with Highest Percentage Shares (Weekly Average Values)

	Exiting at SFO (Category #)	Percentage %	Entering at SFO (Category #)	Percentage %	Notes
July 2003	D B A	42.4 9.4 8.7	D B C	42.8 8.5 8.4	Area A with 7.4% (exiting)
August 2003	D B A	44.9 9.3 7.6	D B C	44.5 8.6 7.8	Area A with 5.9% (Entering)
September 2003	D B A	44.6 10.4 7.1	D B C	45.2 8.6 7.9	Area A with 5.7 % (Entering)
October 2003	D B A	46.0 10.3 7.4	D B C	55.3 11.0 9.4	Area A with 5.5 % (Entering)
November 2003	D B C	44.0 9.7 7.6	D B C	42.9 9.4 8.9	Area A with 7.3% (Exiting) and 5.4% (Entering)
December 2003	D B C	39.3 10.2 7.2	D C B	42.4 9.7 9.4	Area A with 7.2 % (Exiting) and 5.5 % (Entering)
January 2004	D B A	40.8 11.7 8.4	D B C	39.8 10.5 8.7	Area A with 6.9 % (Entering)
February 2004	D B A	44.4 10.4 7.7	D B C	45.5 9.4 8.8	Area A with 6.4 % (Entering)
March 2004	D B C	45.9 9.5 7.0	D B G	46.5 8.8 8.1	Area A with 6.9 % (Exiting) and 6.6 % (Entering)
April 2004	D B A C	44.5 9.5 7.1 7.1	D B C	43.7 9.2 7.8	Area A with 6.4 % (Entering)

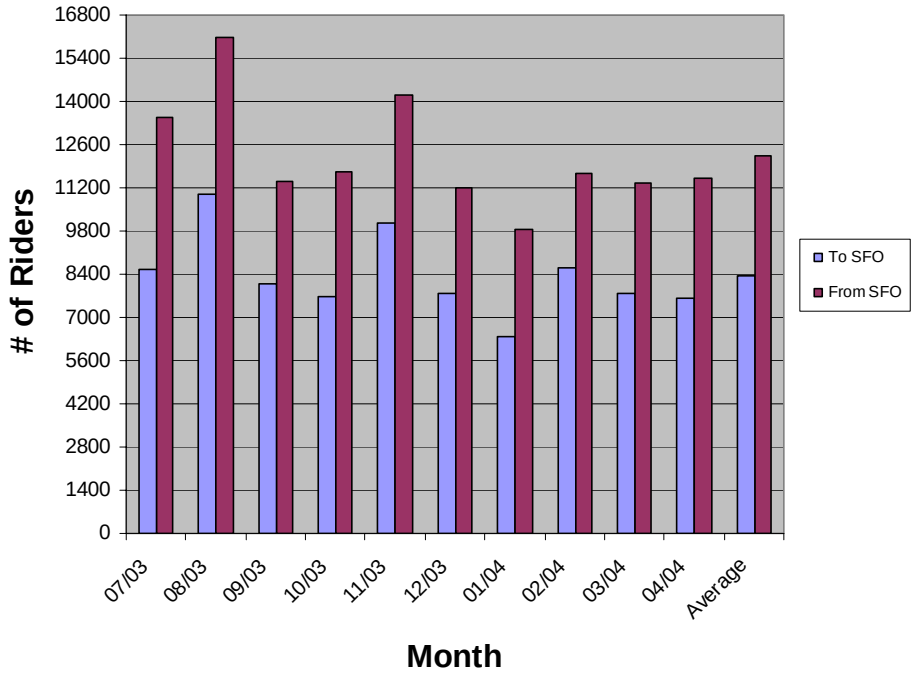

Figure 4 Total Monthly Sunday BART Ridership

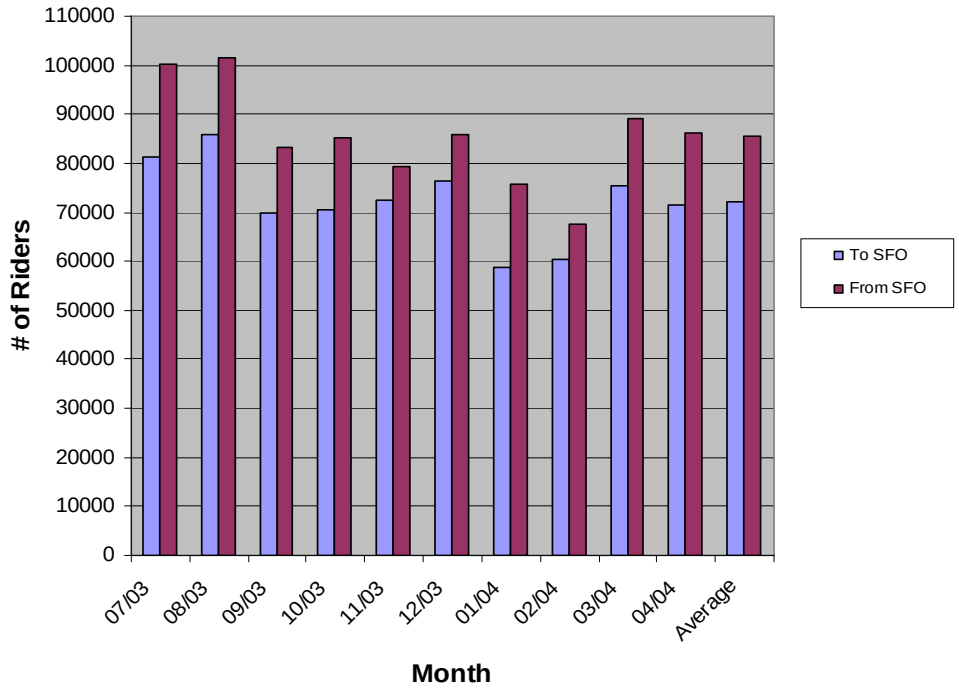

Figure 5 Total Monthly Weekly Average BART Ridership

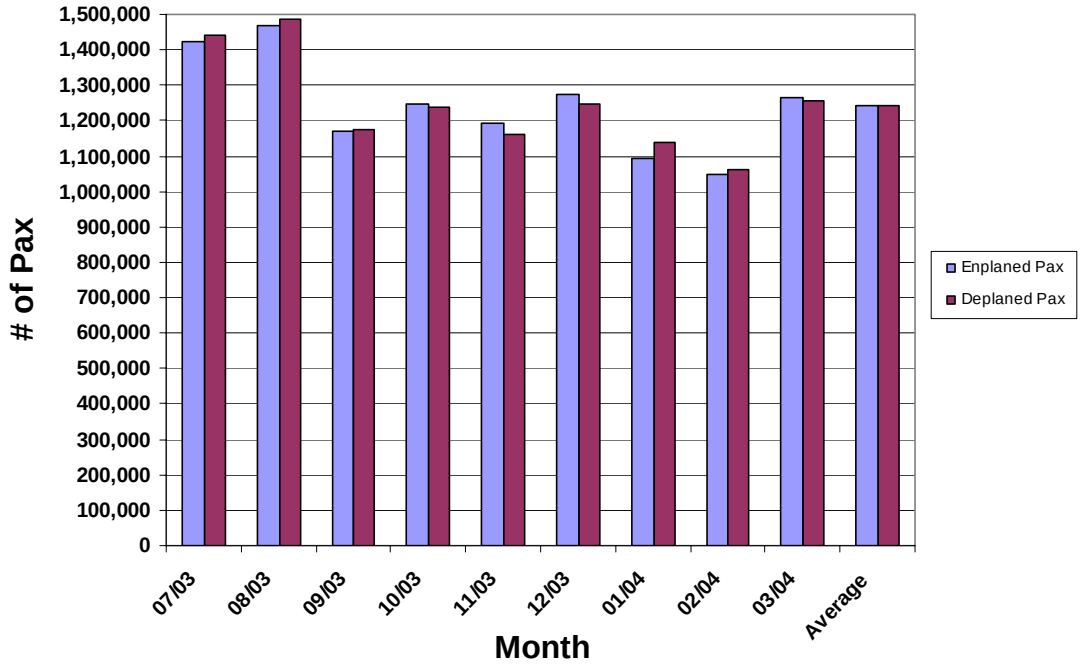

Figure 6 Monthly Enplaned vs. Deplaned Passengers at SFO