TECHNICAL MEMORANDUM

SAMPLE DESIGN FOR A HOUSEHOLD

PANEL SURVEY

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Sampling Methodology

The simplest sampling methodology would be to draw a simple random sample from the entire PSCOG region. However, such a sample is likely to provide very little information on a number of segments of the population that would be of considerable concern to the users of the panel survey data. Therefore, it is recommended that a stratified sampling methodology be adopted, where the strata define those subgroups of the regional population that are of importance to the users of the data. Later in this report, alternative stratification schemes are described.

Within a stratification scheme, two options exist for defining the sample size in the strata. The first method is to use a uniform sampling rate. This means that, for example, if the overall sampling rate is to be 0.1 percent of the population, each stratum defined will be sampled at 0.1 percent. In this case, stratification serves to ensure that each of the groups of the population defined by the strata is represented in the panel in the same proportion as the groups occur in the actual population. This also means, however, that the various strata will have widely differing sampling errors for statistics derived just from the stratum. This is because the sampling error is a function of the absolute number of samples, not the sampling rate.

The second option for sampling is to use a different sampling rate in each stratum (technically called "stratified sampling with variable sampling fraction"). This method can be used to equalize sampling error between different strata by selecting the samples in different strata to be the same in number but different in sampling rate. Also, some strata can be sampled so that some acceptable minimum number of households is included in the stratum, where concern is less with the sampling error per se, but more with ensuring that sufficient households are included to permit some analysis to be performed on the households in the stratum.

The second of these methods -- variable sampling rates -- is recommended, because of the various requirements that can be expected to be placed on the data. It is also recommended that the sampling rate be determined in some strata as a function of equating the sampling errors and in other strata as a means to ensure sufficient data for analysis of the households, but without emphasis on the size of the sampling error.

Selecting a Stratification Scheme

The first stratification that appears essential for the panel survey is between users and nonusers of transit. This stratification should be designed to equalize sampling error between the two strata, so that data prepared for each stratum is of equal accuracy. Thus, supposing that a total panel sample of 1,000 households was to be used, 500 should be from households that include at least one transit rider, and 500 should be from households with no transit riders.

The second stratification should be made with respect to location of residence, to ensure that all of the counties in the region are represented in the panel, and that any important subareas within a county are also included. In this case, equal sampling error is not an issue, but rather insurance that no county has too few households in the panel to permit computation of some statistics for that county. It is recommended, therefore, that this stratification be used to ensure that at least 75 households are selected from each county, irrespective of transit usage or any other stratification variable used.

The third stratification that should be considered is with respect to location of workplace, although this may be redundant given the stratification between transit users and nonusers. It is recommended that the stratification in this case be to three cases:

a. One or more workers in the household with a workplace in the Seattle CBD.
b. All workers in the household with a workplace other than in the Seattle CBD.
c. Households with no workers, or with workers whose workplace is their home.

Consideration should be given to ensuring that the panel contains equal numbers of CBD-working households who are transit users, and CBD-working households that are not transit users. This would provide equal accuracy in data concerning each of these two groups. It is probably unrealistic to expect that the non-CBD working households can be selected to have equal numbers of transit users and nonusers, so that in this stratum, a minimum requirement of 75 transit-user households should probably be considered.

Three other variables can be considered as being appropriate for possible use in stratifying households for the panel survey, given that the primary uses expected to be made of the data include travel forecasting updates and tracking changes in household demographics and associated travel behavior. These variables are:

a. Household size
b. Vehicle ownership/availability
c. Worker participation

If trip generation is of some importance in the analysis of results of the panel survey, then it is recommended that the sample be stratified by both household size and vehicle availability or ownership. The household size should be divided into categories of 1 person, 2 persons, 3 persons, 4 persons, 5 persons, and 6 or more persons. Vehicle ownership (or availability) should be divided into 0 vehicles, 1 vehicle, 2 vehicles, 3 vehicles, and 4 or more vehicles. Worker participation should be divided into categories of none (duplicative of the workplace category of none), one worker, and two or more workers. It is recommended that the household size/vehicle ownership stratification be the basic one that drives the entire sampling process. These two variables will impact most of the statistics to be measured in the survey, as well as being very important for analyzing trip generation. Ensuring a sample that is spread over these two variables in a two-way stratification is likely to be the best way to serve a number of purposes. It is, therefore, recommended that a variable sampling rate be used for these categories, aimed at creating a sample that is almost uniformly distributed over the categories. A possible sampling strategy is shown in Figure 1. Based on 1980 Census Data for the Puget Sound region, the actual numbers of households in each category should be modified. A cross-tabulation should be obtained of the census data on household size and vehicle ownership and adjustments made to sample sizes as appropriate to reflect the data from the census.

With the basic household size and vehicle ownership stratification, the other stratifications can be applied in two alternative ways. First, additional stratifications can be added by defining minimum required sample sizes in each stratum for each of the household size and vehicle ownership strata. Alternatively, other stratifications can be handled as independent stratification schemes. In the first procedure, for example, it could be specified that workforce participation should be stratified as shown in Figure 2. In the second procedure, however, it might be specified that each household size category, summed over all vehicle ownership categories must have a certain number of each category of workforce participation, e.g., by stipulating that one-person households should include 20 households with no workers and 30 with a worker; etc. as shown in Figure 3.

FIGURE 1

POSSIBLE SAMPLING SCHEME FOR FIRST-STAGE OF PANEL SAMPLE

VEHICLE OWNERSHIP	HOUSEHOLD SIZE						
	1	2	3	4	5	6+	TOTAL
0 Vehicles	25	50	50	50	25	25	225
1 Vehicle	25	50	50	50	25	25	225
2 Vehicles	0	50	50	50	50	25	225
3 Vehicles	0	25	50	50	50	25	200
4+ Vehicles	0	0	25	25	25	25	100
TOTAL	50	175	225	225	175	125	975

Both of these alternative procedures can be applied to stratification by workplace, by residence location, and by transit user and nonuser. It is likely to be better to design a cross-stratification between residence location, workplace, and transit use to ensure that the sample contains both transit users and nonusers to the CBD, and that some transit users are included who do not work in the Seattle CBD. However, the stratification can be done independently of the household size and vehicle ownership stratifications, in the sense that no joint distribution of all of the stratification categories need be stipulated.

Determining the Sample Size

The principal advantages of a panel survey are:

a. The ability to determine dynamic changes in households and their travel
b. Reduction in the cost of repeated surveys through not needing to undertake sampling on each new occasion
c. Reduction in the sample size required to achieve a given level of accuracy at given confidence

The reduction in cost offered by a panel survey is dependent in part on the extent of replacement required from year to year. The more of the panel that must be replaced, the less will be the savings from the panel. Similarly, the sample size requirements are based on both the amount of replacement required in the panel and the correlation between the two most recent surveys for those households that are in the sample on both occasions. For example, suppose that two

FIGURE 2

POSSIBLE THIRD-LEVEL STRATIFICATION BY WORKFORCE PARTICIPATION

NO WORKER HOUSEHOLDS:
VEHICLE OWNERSHIP HOUSEHOLD SIZE

	1	2	3	4	5	6+	TOTAL
0 Vehicles	10	20	20	20	10	10	90
1 Vehicle	10	20	10	10	5	5	60
2 Vehicles	0	10	10	10	5	5	40
3 Vehicles	0	5	10	5	5	0	25
4+ Vehicles	0	0	5	5	5	0	15
TOTAL	20	55	55	50	30	20	230

ONE WORKER HOUSEHOLDS:
VEHICLE OWNERSHIP HOUSEHOLD SIZE

	1	2	3	4	5	6+	TOTAL
0 Vehicles	15	20	20	20	10	10	95
1 Vehicle	15	20	20	20	10	10	95
2 Vehicles	0	20	20	20	15	10	85
3 Vehicles	0	15	20	25	25	15	100
4+ Vehicles	0	0	15	15	15	10	55
TOTAL	30	75	95	100	75	55	430

TWO+ WORKER HOUSEHOLDS:
VEHICLE OWNERSHIP HOUSEHOLD SIZE

	1	2	3	4	5	6+	TOTAL
0 Vehicles	0	10	10	10	5	5	40
1 Vehicle	0	10	20	20	10	10	70
2 Vehicles	0	20	20	20	30	10	100
3 Vehicles	0	5	20	20	20	10	75
4+ Vehicles	0	0	5	5	5	15	30
TOTAL	0	45	75	75	70	50	315

FIGURE 3

ALTERNATIVE STRATIFICATION FOR WORKFORCE PARTICIPATION

WORKFORCE PARTICIPATION	HOUSEHOLD SIZE						
	1	2	3	4	5	6+	TOTAL
NO WORKERS	20	55	55	50	30	20	230
ONE WORKER	30	75	95	100	75	55	430
2+ WORKERS	0	45	75	75	70	50	315
TOTAL	50	175	225	225	175	125	975

successive surveys measure use of bus for the journey to work. On the first occasion, suppose that 10 percent of households report a work trip by bus. Suppose that this decreases to 8 percent on the second occasion. If a sample of 1,000 households was used on each occasion and the samples were drawn independently of each other, then the sampling error on the 2 percent change in bus use would be ± 0.0128, which gives 95 percent confidence bounds of ± 0.0251. In other words, we would not have 95 percent confidence that there was a change in the percentage of households with work trips by bus from a sample of 1,000 households drawn independently on tow occasions.

Suppose, now that a panel is used for the two occasions, and suppose that 20 percent of the panel is replaced on the second occasion. A range of situations arise, depending on the correlation between the 800 households that appeared in the sample on both occasions. Suppose that 80 households out of the common 800 had a work trip by bus on the first occasion. Suppose that 72 of these households still report a work trip by bus on the second occasion (i.e., 90 percent of the households remain as bus using households). This implies that among the 200 added households, only 8 households report using bus to work, which represents a 4 percent use rate by the new households. Given the sampling error on any one occasion, this 4 percent is possible, even if the population average is 8 percent. The correlation between the households common to both occasions is 0.9434. In this case, the sampling error on the 2 percent change is ± 0.003378 and the 95 percent confidence bounds are ± 0.00662. Therefore, from the panel, we are 95 percent sure that a real decrease in bus use has occurred from occasion 1 to occasion 2, ranging between 1.3 percent and 2.7 percent. To achieve this same result from two independent samples would require that over 14,300 households were sampled on each of the two occasions. Again, suppose that there are 800 households in common between the two occasions. Suppose now, however, that only 40 households of these 800 are bus riders on both occasions, so that 40 households on the first occasion that were bus riders are no longer, and 32 households that were not bus riders on the first occasion are on the second. In this case, the correlation between the two occasions is 0.478. The sampling error for the 2 percent change is now ± 0.09719 and the 95 percent confidence bounds

are ± 0.01905. In this case, we have 95 percent confidence in there having been a change in the percentage of bus riders, but with a 95 percent confidence range from 0.1 percent to 3.9 percent. The panel data would also show that there had been a substantial turnover in bus patrons between the two occasions. Thus, while the accuracy is reduced by the lower correlation between the two occasions, so that a sampling error gain is now much less apparent over the two independent samples, the panel survey in this second case demonstrates that the change results from changes in the households that are bus riders, rather than from a decrease in bus riding. Even with the reduced error benefits, it would still require a sample of over 1,730 households for the independent samples to produce the same accuracy as the panel sample.

Because of the interaction of the replacement of the panel and the correlation between the two occasions, added to the variability of the proportions of the sample found to exhibit a given characteristic on each of the two occasions, the determination of a required sample size is complex. Table 4 shows a sampling of values of sample size required for alternative values of the correlation, the replacement proportion, and the proportion of the population with a specific characteristic. The sample sizes are computed for the situation in which the change must be found to be significant at a 95 percent confidence level.

The table shows clearly that the sample size is dictated far more strongly by the size of the change and the correlation between time 1 and time 2, and is relatively insensitive to the relative proportions that a characteristic occurs in the panel and to the proportion of the panel that must be replaced. It is also clear from this table that two independent samples require a considerably larger sample size for all situations represented by the table. The proportion of the panel replaced must be much greater than 30 percent, and the correlation between time 1 and time 2 must be very low (near 0.1) before the independent samples will be very close to the panel requirements. In no circumstances can the panel survey require a larger sample for given accuracy than two independent samples. Conceptually, this means that panels are much more efficient than independent samples except when the whole idea of a panel virtually falls apart because almost everyone has to be replaced, or when the change between the first occasion and the second is so great, that the panel members display characteristics on the second occasion that it is as though the panel had been replaced by an unlike group.

Table 4 also suggests that, for characteristics that are held either by a significant majority or minority of the panel (e.g., greater than 70 percent or less than 30 percent), for reasonable ranges of panel replacement (up to 30 percent), and for reasonable correlations between the first and second occasion (0.5 and up), a sample size of between 1,000 and 1,500 will generally suffice to show significance of a change of 2 percentage points or more in a characteristic. In many instances, significant differences could be determined from much smaller samples, if the correlation between occasions is very high (e.g., around 0.8 and up).

Therefore, depending on budget available, a panel of between 1,000 and 1,500 households will suffice to give a high degree of discrimination on whether or not real change has occurred between one occasion and another.

TABLE 4

SOME EXAMPLES OF SAMPLE SIZES REQUIRED FOR DIFFERENT PANEL CHARACTERISTICS

Change Time 1 -Time 2	Percent of Panel Replaced	P_1	Q_1	P_2	Q_2	CORRELATION 0.3	0.5	0.7	0.9	IND. SAMPLE
0.02	10	0.5	0.5	0.52	0.48	3465	2527	1549	528	4802
		0.3	0.7	0.32	0.68	2911	2123	1301	443	4034
		0.1	0.9	0.12	0.88	1248	910	558	190	1729
0.05	10	0.5	0.5	0.52	0.48	554	404	248	84	768
		0.3	0.7	0.32	0.68	466	340	208	71	645
		0.1	0.9	0.12	0.88	200	146	89	30	277
0.02	20	0.5	0.5	0.52	0.48	3576	2668	1675	586	4802
		0.3	0.7	0.32	0.68	3004	2241	1407	492	4034
		0.1	0.9	0.12	0.88	1287	960	603	211	1729
0.05	20	0.5	0.5	0.52	0.48	572	427	268	94	768
		0.3	0.7	0.32	0.68	481	359	225	79	645
		0.1	0.9	0.12	0.88	206	154	96	34	277
0.02	30	0.5	0.5	0.52	0.48	3694	2825	1824	658	4802
		0.3	0.7	0.32	0.68	3103	2373	1532	553	4034
		0.1	0.9	0.12	0.88	1330	1017	656	237	1729
0.05	30	0.5	0.5	0.52	0.48	591	452	292	105	768
		0.3	0.7	0.32	0.68	496	380	245	88	645
		0.1	0.9	0.12	0.88	213	163	105	38	277