THE ROLE OF SAS IN INFLUENCING MAJOR TRANSPORTATION DECISIONS FOR A LARGE PRIVATE EMPLOYER

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Introduction

This paper describes the valuable applications of the Statistical Analysis System (SAS) in relation to a major transportation study performed by the Union Carbide Corporation—Nuclear Division (UCC-ND) of Oak Ridge, Tennessee. A recent study performed by the Transportation Center of the University of Tennessee with the assistance of The Computer Applications Division of UCC-ND accomplished the following objectives:

1. inventoried existing transit services within and between three UCC-ND plants;
2. monitored the travel patterns of approximately 1,100 company vehicles for one month; and
3. recommended transit improvements and fleet management strategies to transport employees more effectively and economically and to conserve energy.

The computer analysis used to accomplish these objectives was performed entirely by SAS. Procedures such as CCNART, FREQ, MEANS, PLOT, and others were used to present simple statistics and detailed graphics which were concise and informative for management. Through these techniques, SAS has proven to be an effective facilitator of applied research in the increasingly important area of transportation for private industry, while also serving as an effective managerial tool for transportation decisions. Applications of SAS/GRAPH are particularly informative to management since color slides from SAS/GRAPH simplify data analyses and presentations while vividly portraying transportation facts in a very discernable format.

Background Information

Transportation and related energy problems are not confined merely to public agencies or individuals. Employers are faced with increasing pressures to transport personnel and materials efficiently and economically. Providing these transportation services is further complicated by the rising costs and reduced availability of petroleum products. Establishing effective and efficient transportation services requires sound transportation planning and innovative management strategies.

As with many other major employers, transportation services within and between the individual UCC-ND plants have evolved from numerous sources as individual needs arose. Earlier managerial decisions helped to solve an immediate problem but did little to mold the existing transportation system into a total, optimum transportation service. An earlier supply of inexpensive fuel and adequate capital for purchasing equipment has caused many major industrial employment centers with physically separate facilities to establish vehicle use patterns that are incompatible with current costs and fuel availability. Such vehicle use patterns and underlying policies must now be reevaluated. More comprehensive, long range planning is needed to provide transportation services that will satisfy user needs without productivity losses and that will use fuel and vehicles efficiently.

Several unique transportation conditions exist at the UCC-ND facilities in Oak Ridge. Efficient use of over 1,100 vehicles to transport personnel and materials is not a small undertaking. Similarly, operating intraplant and interplant transit services to satisfy diverse travel demands, varying security requirements, and differing plant layouts is difficult. In terms of total ridership, the UCC-ND transit system is the sixth largest operation in the entire State of Tennessee.

Finally, reductions in the availability of petroleum directly affect transportation. The reduced fuel allocation of approximately 30 percent vividly highlights the need for energy conservation and wise management of a limited resource. UCC-ND has made impressive strides in reducing fuel consumption through innovative measures such as the use of smaller, more fuel efficient vehicles and electric vehicles, and vehicle fuel conversions to propane and gasohol. However, additional reductions in fuel consumption are desired through careful synchronization of travel demands and transportation services.

Data Collection

Two research instruments were designed and administered to obtain information about vehicle usage and transit ridership characteristics. Both surveys were administered during March 1980.

Trips made in company vehicles were monitored by entering the trip information required on a vehicle usage log. These forms required drivers to provide the following information for each vehicle trip:

1. Vehicle license number;
2. Assigned plant division;
3. Date;
4. Signature of operator;
5. Starting and ending times;
6. Odometer readings;
7. Trip origin;
8. Trip destination;
9. Total number of vehicle occupants; and
10. Trip purpose.

From this information, trips were identified by vehicle, division, day of the week, time of day,
occupants were perhaps the most useful data. The origin and destination information addressed specific travel demands, while vehicle occupant indicated vehicle utilization and were essential for converting vehicle trips into person trips.

The transit boarding and alighting survey was designed to identify travel demand currently being met by the existing transit service. After careful consideration, the researchers concluded that a detailed passenger survey would be difficult to administer, and although individual passenger information would be nice, it was not warranted. Therefore, a form completed by the transit driver was developed to obtain the following information:

1. Type of transit service;
2. Date;
3. Signature of operator;
4. Weather; and
5. Number of riders boarding and alighting at identified locations.

Although this information did not trace the actual origin and destination of a specific transit rider, important transit ridership totals and characteristics were revealed by minimum data collection and passenger inconvenience. The resulting data revealed important usage characteristics and ridership trends.

General Analysis of Data

Once the data were key punched and placed on tapes, several computer programs from the SAS package were used to perform numerous data manipulations and calculations. SAS/GRAPH was particularly useful since, throughout the entire analysis process, emphasis was placed on graphical presentation of information. This visual formatting of data was useful to researchers in developing recommendations and informative for UCC-ND officials responsible for major transportation decisions.

First, SAS procedures were used to identify the dates on which survey data were collected and the amounts obtained. This information was used to check the consistency and validity of the data. From these "quality control" reviews, the data base was found to be very acceptable. Next, individual categories or responses from each survey were reviewed to determine the percent of data missing for any specific response. Several horizontal bar charts were produced and showed a range of 1.7-7.0% missing observations per individual category. As an example, a missing observation might involve an omitted vehicle occupancy or an illegible odometer reading. However, these missing observations presented no major problem to the analysis of the resulting data.

In addition to the computer graphics used for verifying the quality of data, numerous other graphics were produced to aid researchers and decision makers. The following sections highlight the use of computer graphics in analyzing the transit and vehicle fleet data.

Analysis of Transit Data

As mentioned previously, no major problems exist with the transit data. An investigation of individual service type by the total days during which data were collected revealed that an occasional minor adjustment might be appropriate. By taking the aggregate ridership totals for each service type and adjusting upward or downward based on 21 ridership days in March 1980, the total ridership changed from 37,126 riders counted to 38,551 riders. This +3.842 adjustment is relatively insignificant but logical in its derivation.

Pie charts were used to illustrate transit riderships per service type. Horizontal bar charts were used also to illustrate ridership per service type, but the analysis was taken one step further since the individual services could be ranked in descending sequence. This technique vividly shows which services are being most heavily utilized. Figure 1 shows the monthly ridership totals for 14 transit services at UCC-ND.

Figure 2 shows the riderships for these same 14 transit services grouped by intraplant or interplant service. It is interesting to note how this technique displays totals as well as individual ridership levels for each type of service. Differing patterns distinguish respective services for black and white copies, while contrasting colors were used for slides in presentations to UCC-ND management officials. One of the most useful capabilities of the Computer Applications Division of UCC-ND is its ability to route GCHART output directly to 35mm film for quick production of slides. This unique capability of producing slides immediately afforded the researchers great responsiveness to management's requests and essentially saved three to four days from earlier processing requirements.

Figure 3, although similar in its development, graphically illustrates the much higher ridership levels experienced by regular intraplant transit services. Further use of SAS procedures showed that:

1. The demand for current service peaks three times a day as opposed to the morning and afternoon peaks normally encountered by public mass transportation.
2. The mid-day or lunch peak is, in fact, the greatest and accounts for about one-third of the total daily ridership.
3. Riderships are slightly higher on days of inclement weather which may reflect the expected decrease in walk trips.
### TRANSPORTATION DATA

**MONTHLY TRANSIT RIDERSHIP**

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<thead>
<tr>
<th>Service Type</th>
<th>Frequency (FREQ)</th>
<th>Ridership (RIDETOT)</th>
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<tbody>
<tr>
<td>Y-10</td>
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</tr>
<tr>
<td>X-10</td>
<td>3</td>
<td>11,720.00</td>
</tr>
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<td>7,310.00</td>
</tr>
<tr>
<td>INTERPLANT</td>
<td>3</td>
<td>5,840.00</td>
</tr>
</tbody>
</table>

**LEGEND: VEHCODE**

- **Y-10** Rapid Taxi
- **X-10** Loop Taxi
- **X-25** Rapid Taxi
- **X-25** Loop Taxi
- **X-25** Demand Taxi
- **X-25** inc. Weather
- **X-25** inc. Loop
- **X-25** inc. Shuttle
- **X-25** inc. Lunch

** FIGURE 1. MONTHLY TRANSIT RIDERSHIP FOR INDIVIDUAL SERVICES **

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** FIGURE 2. INTRAPLANT VERSUS INTERPLANT SERVICES **
FIGURE 3. MONTHLY TRANSIT RIDERSHIP GROUPED BY TYPE OF SERVICE
These analyses revealed to management that a disproportionate amount of resources are currently being devoted to interplant transit services. The resources are disproportionate in terms of current ridership levels since estimates show that 31.2% of all transit vehicles transport only 15.2% of the total transit ridership. At least two explanations exist for this occurrence. First, the travel demand may not exist. Second, current services may inadequately satisfy existing travel demands. Further graphical analysis of vehicle travel data provides further insight into which of these two conditions is most appropriate.

**Analysis of Vehicle Date**

Using SAS procedures, a number of sorts were performed to determine major origins and destinations of vehicle trips. Primary trip ends were then located manually and marked on maps to identify important origins and destinations visually. The analysis was taken one step further as major origin-destination pairs or actual point-to-point travel demands were determined by using a ranked pointer menu. Once this information was prepared by computer analysis, the origin-destination data or two-way vehicle trips per month between various locations were plotted on maps by using "desire lines." The use of desire lines connecting particular locations on a map is a helpful visual technique which assisted researchers in understanding travel patterns. These maps were used for studying existing vehicle travel and for designing transit systems to serve these needs better.

Vehicle occupancies are very important in relating vehicle trips to person trips and in revealing the efficiencies or inefficiencies of employees using company vehicles. Five charts were generated to show the overwhelming dominance of single occupant operations. Single occupant trips appeared to be 60.5% of all vehicle trips. The average vehicle occupancy was 1.56 occupants/vehicle. More detailed graphical analyses of vehicle occupancies in relationship to trip purpose, time and trip length revealed the following information:

1. **Vehicle occupancies did not vary greatly by trip purpose except for the expected low occupancy rate (1.05) for security patrol trips.**

2. The highest occupancies occurred in the morning from 8:00-8:59 (1.73), at lunch from 12:00-12:59 (1.67), and at quitting time from 4:00-4:59 (1.66). These slightly higher occupancies were logical, and the consistency between the research data and reality was reassuring.

3. **Vehicle occupancies by trip length did not reveal any startling trends, but it did appear that trips between 11 and 50 miles in length had the highest occupancy rate (1.79).** Trips in this category would include trips to Knoxville and McGhee Tyson Airport.

4. The overall vehicle occupancy of 1.56 passengers per vehicle appeared acceptable; but the fact remained that 60.5% of all trips (88,123 of 145,606) were made with three or more occupants resulting in an average overall vehicle occupancy which may be slightly misleading.

Another important trip characteristic related to the length of the trip. Other graphs showed that 104,266 vehicle trips were one mile or less in length. This represented 71.6% of all vehicle trips and showed the overwhelming predominance of short trips. The large number of short trips has direct significance on potential transit use since it suggests that current transit systems are poorly utilized and may be inadequately serving employee travel demands.

Other graphic procedures advanced the trip length analysis one step further to analyse selected trip purposes and day of the week for these short vehicle trips. Return trips and meeting trips were selected for individual attention since these trips could possibly be accommodated by transit because of their short length within plants. The data appeared to be fairly homogeneous, but travel is lower on Friday. The level of detail can be so refined that meetings per day for each plant can be investigated. X-25 appears to maintain or even slightly increase the number of meetings on Friday, while X-10 and Y-12 apparently have 28% and 22% percent fewer Friday meetings, respectively.

Horizontal bar charts showing average trip length and average trips per vehicle for divisions within a specific plant were generated also. This information was evaluated with regards to a division's job mission, number of employees, and employee work locations. This vehicle trip information by division also furnishes clues about divisional efficiencies or inefficiencies. This information can be of vital importance to management in assessing vehicle fleet adjustments.

Final graphical analyses showed the vehicle trips by trip purpose for each plant. These three dimensional block charts are impressive and can be designed to illustrate various facts dramatically to management.

**Analysis of Vehicle Fleet**

In addition to the transit analysis, a thorough review of the data from the vehicle logs revealed several interesting facts. Many vehicles were being used infrequently, and travel mileages were low. Although SAS/GRAPH was not specifically used in these analyses, other SAS procedures were used to group and rank vehicle information from the March vehicle logs and various in-house maintenance records.
Study Conclusions

As a result of this research which has relied heavily upon many SAS procedures, several of the more important and identifiable conclusions were:

1. Present transit systems are not being utilized to desired levels.
2. Although the origins and destinations of person trips illustrate a much greater propensity for intraplant travel, existing transit services devote a disproportionate amount of resources serving interplant travel.
3. Increased transit ridership should result from system improvements and a decrease in auto availability.
4. Vehicles in the current fleet are severely underutilized.
5. A disproportionate amount of vehicle trips are less than one mile (71.6%) and can be more efficiently accomplished or eliminated.
6. Single occupant vehicles make 60.5% of vehicle trips. Increased vehicle occupancies would result in significant trip reductions.
7. Energy savings can be achieved through vehicle fleet and transit system modifications.

Major Recommendations

This research resulted in four major recommendations which were presented to UCC-ND management. Basically, the four recommendations were:

1. Relocate existing transit resources to serve predominant intraplant person trip better. Several existing interplant shuttles should be replaced by informal, but organized, carpooling arrangements which would not be as labor intensive.
2. Reduce the current vehicle fleet by at least 133 vehicles (about 10% of fleet) which are infrequently used to transport employees and materials. Specific vehicles were identified. Further reductions should be considered in one year.
3. Develop criteria for an on-going vehicle utilization review process which would essentially use existing maintenance records to review and adjust fleet size continually depending on current utilization of vehicles.
4. Review transportation planning, administration, and operations in each plant so that control and responsibility is centralized and definable.