Case Study
An Engineering-Based Service Function for Bus Operations

This case study shows how a transit agency might develop an engineering-based service function that it could use to evaluate options for improving transit service. Using such a service function, the agency could determine how much service would improve for various operating and investment strategies. The cost effectiveness could be measured by comparing the improvements in service to the cost of the investments. By considering cost-effectiveness, the transit agency could determine whether it would be best to improve the existing services or to extend these services. They might conclude that the most cost-effective approach would be to increase bus frequency – but they might also eventually decide that they could not afford to do so.

Commuters in large cities usually have a choice of driving or taking transit. Public officials advocate greater use of transit as a way to reduce highway congestion, improve air quality, and reduce emissions of greenhouse gases. However, commuters will only take transit if they perceive the cost and service levels to be acceptable in comparison to driving. Transit agencies therefore need to understand how long it will take commuters to get from home to work if they decide to take the bus; if the transit agency can provide better service, then perhaps it can attract more riders. What is needed is an engineering-based service function that can predict trip time for a commuter based upon existing or potential transit schedules.

Any commuter's journey to work can be divided into individual segments. For example, one commuter's transit journey might include the following:

- Walk to bus stop (5 minutes)
- Wait for bus, which operates every 10 minutes (0-10 minutes)
- Ride bus 2 miles to subway station (5-10 minutes)
- Transfer from bus to subway platform (3 minutes)
- Wait for subway train, which operates every 5 minutes (0-5 minutes)
- Ride train 3 miles to destination, with five stops (12-15 minutes)
- Exit station and walk to destination (7 minutes)

The total trip could take as little as 36 minutes, if the connections are perfect and there are no delays on the bus or the subway. On the other hand, if the commuter just misses the bus and also just misses the train, and if there are delays for both the bus and the train, then the journey could take 55 minutes. The average trip is likely to be about 45 minutes.

After a couple of weeks taking this route, the commuter would know when to leave home in order to be on time for a meeting and when to leave home in order to experience the least delay. The commuter relies on experience and does not require an engineering-based service function.

The transit agency, however, has designed the bus routes, built the subway system, determined how many stops to make along the bus routes, and established schedule frequencies. They also have extensive experience in travel time along the bus routes and the time required at bus stops and at subway stations. They therefore can develop equations that could be used to predict service for any commuter under any set of operating conditions and any assumptions about future bus routes and subway extensions. They also know, from census data and surveys, where people live and where the jobs are. They can therefore select a representative sample of commuters and calculate the following for each of them:

- Access to the system
    - If distance from home to subway is less than 0.25 miles, assume the commuter will walk to the subway at an average speed of 3 miles per hour.

  - If distance from home to subway is more than 0.25 miles, assume that the commuter will take a bus if there is a bus stop within 0.25 miles; the time to walk can be estimated assuming an average speed of 3 miles per hour.
  - If there is neither a subway station nor a bus stop within 0.25 miles, assume that the commuter will drive to work.
- Wait for bus (assume to be between 0 and the average time between buses during rush hour)
- Ride bus to subway station (estimate time based upon observed travel times, scheduled frequency of stops, and time required for stops along route)
- Transfer from bus to subway platform (estimate based upon distance from bus to platform, expected congestion at stairways or escalators, and time required to purchase ticket)
- Wait for subway train (assume to be between 0 and the average time between trains during rush hour)
- Ride train to destination (estimate time based upon distance, speed limits, train acceleration and braking capabilities, number of stops, and time required for loading and unloading at each station)
- Exit station and walk to destination (estimate based upon distance and walking speed)
- Sum all of the times to determine the minimum, expected, and maximum travel times for each user.

This is an engineering-based service function because it provides a way to predict trip times and reliability as functions of engineering parameters, operating strategies, and network design. This process could be used to estimate the changes in service, for particular groups of people, that would result from increasing the frequency of bus service, adding bus routes, creating an express-bus lane, or expanding the subway system.

Figure 1 Reliable, frequent bus service in England's Lake District

Visitors can leave their cars at home, take the train to Windermere, and connect to buses that offer frequent, reliable service throughout the entire Lake District. The views of the mountains and lakes are more important than speed.

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