Case Study
Weighting Schemes for Evaluating Options for Increasing Bus Capacity

Weighting schemes cannot be accepted as an objective way to compare alternatives. This hypothetical case study illustrates how each group interested in expanding the capacity of a transit system can devise a weighting scheme that will rate their preferred option as the best option.

Table 1 shows how four hypothetical options for improving the performance of a bus system might affect various aspects of performance. The system currently has 300 buses, some of which are old and inefficient. Strategies for improving performance of the system include buying new buses, creating a busway within the downtown area in order to allow buses to avoid congestion, and developing a control system that would improve performance by enabling dispatchers to monitor the location of and the number of people on every bus. Buying new buses would have two effects: increasing the number of scheduled operations, thereby improving service and allowing the system to handle more passengers. With new buses, the oldest 25 buses could be retired, and the average fuel efficiency of the fleet would increase while the average emissions would decline. If new buses were purchased, it would be possible to reduce emissions by ordering cleaner, but more expensive, hybrid buses. If more buses were acquired, the agency planned to create a new servicing facility for the buses on land that the agency owns; several businesses that currently rent space from the transit agency would have to be moved from this site. If the city were to build a busway and create some bus-only lanes, it would be able to provide much faster service and run additional trips without increasing the size of the fleet. Finally, if the city were to install a state-of-the-art control system, it would be able to get some improvement in travel times, ridership, and emissions for a much lower cost than any of the other options.

Table 1 Predicted Cost and Performance for Expanding Capacity of a Bus System

	Cost	Improvement in Travel Times	Increase in Ridership	Reduction in Emissions per Bus-Mile	Families & Businesses to Relocate
Buy 100 new buses	$50 million	5%	20%	10%	10
Buy 75 new hybrid buses	$60 million	4%	15%	40%	10
Create a busway	$200 million	20%	30%	8%	30
Install a control system	$20 million	10%	5%	5%	0

None of the proposals dominates all of the others, and three of the proposals look best in terms of at least one of the criteria. Buying hybrids provides the greatest reduction in emissions, while creating a busway would lead to the greatest increase in ridership and installing a control system would be the least costly. Table 2 shows how the proposals rank by each criteria. These are call **ordinal rankings**: first, second, third, or fourth. The total column simply adds the five numbers, so that it is a measure that weights each of the criteria equally. If the best option is the one with the lowest total, then the best option would be to buy 100 new buses.

Table 2 Summing Ordinal Rankings for Each Criterion to Obtain an Overall Ranking

	Cost	Improvement in Travel Times	Increase in Ridership	Reduction in Emissions per Bus-Mile	Families & Businesses to Relocate	Total
Buy 100 new buses	2	3	2	2	2	11
Buy 75 new hybrid buses	3	4	3	1	2	13
Create a busway	4	1	1	3	3	12
Install a control system	1	2	4	4	1	13

It is unlikely that any group of planners or financial managers or government officials or public interest groups would simply accept this result. Those who really want the busway, such as the Transit Agency's Strategic Planning Group, might argue that capacity and ridership are the main goals. They might propose weighting travel time and ridership three times as heavily as the other criteria. As shown in Table 3, creating a busway now looks best.

Table 3 Weighting Scheme Proposed by the Transit Strategic Planning Group

	Cost	Improvement in Travel Times	Increase in Ridership	Reduction in Emissions per Bus-Mile	Families & Businesses to Relocate	Total
Weight:	1	3	3	1	1	
Buy 100 new buses	2	3x3	2x3	2	2	21
Buy 75 new hybrid buses	3	4x3	3x3	1	2	27
Create a busway	4	1x3	1x3	3	3	16
Install a control system	1	2x3	4x3	4	1	24

The operators and the bus passengers association, who really want some immediate relief from overcrowded, unreliable buses, support the concept of bus lanes and busways, but what they most want is new buses. They point out that the busway will take three years to complete, and they also wonder why it should be possible to get hundreds of millions for capital improvements when budgets have been so tight that it has been necessary to freeze salaries for managers and raise fares. The General Manager of Bus Operations argues for high weighting only for cost and ridership, which he views as the key factors, and he claims that relocating small businesses who rented space is not an issue, as those businesses knew very well that their building would eventually be needed for the bus servicing facility. He therefore argued for a revised set of weights as shown in Table 4.

Table 4 Weighting Scheme Proposed by the General Manager of Bus Operations

	Cost	Improvement in Travel Times	Increase in Ridership	Reduction in Emissions per Bus-Mile	Families & Businesses to Relocate	Total
Weight:	2	1	2	1	0	
Buy 100 new buses	2x2	3	2x2	2	2x0	13
Buy 75 new hybrid buses	3x2	4	3x2	1	2x0	17
Create a busway	4x2	1	1x2	3	3x0	14
Install a control system	1x2	2	4x2	4	1x0	16

The local environmental groups, who are a major political force in the city, push very hard that investing in clean buses would have a dramatic impact on the air quality of the city. Furthermore, they argue that the city should set a high standard when it comes to cleaning up the environment. They say that the city should buy however many hybrid buses it can afford to establish a long-term commitment to improving the environment. They also dislike the ranking scheme as structured in all of the above charts, as some of the differences among options are small, while others are very high. They recommend normalizing each of the measures by dividing by the measure for the best option for each criteria where a lower number is better and using the inverse when a higher number is better. Hence, the hybrid bus cost of $60 million would be divided by $20 million, the cost of the lowest cost option, to get a value of 3 for the cost criteria. The hybrid bus value of 40% reduction in emissions is in fact the best, so dividing 40% by 40% would give a value of 1 for the hybrid buses reduction in emissions. They also agree with the notion that there would be no real relocations caused by the creation of the bus servicing facility, so they simply dropped that criteria. Finally, they interpreted the use of weights to be merely an exercise in promoting special interests; once the relevant criteria have been identified, they weight everything equally. Their proposed ranking is shown in Table 5.

Table 5 Weighting Scheme Proposed by Environmental Groups

	Cost	Improvement in Travel Times	Increase in Ridership	Reduction in Emissions per Bus-Mile	Total
Weight:	2	1	2	1	
Buy 100 new buses	50/20 = 2.5	20%/5% = 4	30%/20% = 1.5	40%/10% = 4	12
Buy 75 new hybrid buses	60/20 = 3	20%/4% = 5	30%/15% = 2	40%/40% =1	11
Create a busway	200/20 = 10	20%/20% = 1	30%/30% = 1	40%/8% = 5	17
Install a control system	20/20 = 1	20%/10% =2	30%/5% =6	40%/5% = 8	17

Note that the participants in this example were not debating the information that they were given. They did not dispute the costs of the proposed systems, the ability of each system to improve service or capacity, or the effect of improved service and higher capacity on ridership or emissions. Anyone who has been involved in evaluating such competing projects knows that there could well be extended debates about any or all of these matters. Still, even though all of the participants accepted the predictions of cost and impacts, it was possible to devise a scheme to make any one of the choices look the best.

There is a clear lesson from this case study. It is at best very difficult and more likely impossible to define a "correct" weighting scheme when there are competing options, multiple objectives, and differences in priorities among those who participate in making the decision. The best that can be done is to use some sort of participatory process to reach a consensus as to the weights that are used and the rankings that result. Extreme weights and contorted measurement schemes will be apparent to the majority of a diverse group of people, so if the measurement schemes and weighting options are presented fairly and subjected to general discussion, there will be some hope for reaching consensus.

Figure 1 South Station Bus Terminal, Boston

The bus terminal was constructed in the 1990s in order to replace an old, entirely inadequate terminal that was poorly located with respect to the subway system and the train stations. The new inter-city terminal was built right next to South Station, where it provides for easy connections with both transit and intercity rail.

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