Customers' Perspectives on Using Multilevel Coaches to Increase Rail System Capacity

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Abstract. The numbers and lengths of NJ Transit commuter trains accessing New York's Penn Station are currently at the limits of available capacity during peak periods and there are significant numbers of standees during these periods. NJ Transit is planning to purchase multilevel coaches to address this critical passenger capacity issue. This paper describes the results of a study that was undertaken to determine how the multilevel coaches should be designed to both provide the needed additional system capacity and to reflect customers' preferences. The study focused on interior issues including seating configuration and seat design, which are directly related to the amount of seated (and standee) capacity that the coaches will provide.

A two-part research approach was used to obtain customer input. First, focus groups and product clinics were conducted to get qualitative feedback on the multilevel coach concepts and on specific seat designs. A detailed computer-based survey was administered to the customers to quantify their preferences among key elements of the multilevel concepts and to estimate willingness-to-pay for those elements as a gauge of the strengths of those preferences.

The study found that providing additional seated capacity in the configuration preferred by customers provides a substantial net benefit to NJ Transit's passengers: equivalent to about $2.20 fare value per trip. The benefits are higher for this application because of the degree of crowding that currently exists on these trains, but the study suggests that multilevel coaches and improved interior design have benefits well beyond the capacity increase that they provide.

INTRODUCTION

Using multilevel coaches is a straightforward way to increase regional rail system capacity. However, the customer perceptions of benefits of multilevel coaches, beyond the effects on seating availability, are not well understood in general. In addition, details of how the coaches are configured likely have an impact on perceived benefits. The study described in this paper included a detailed customer research effort designed to provide both general guidance on the design of multilevel coaches for the NJ Transit system and to estimate the level of benefit that customers derive from different features of those coaches. The sections that follow give general background on NJ Transit's capacity issues and multilevel coach plans, describe the research approach used for the study and detail the findings from the research.

BACKGROUND

NJ Transit runs over 285 commuter trains per day into and out of New York City's Penn Station. The North Jersey Coast Line, Northeast Corridor and the M&E all operate from New Jersey, across the Hudson River into New York (Figure 1). During peak periods, most of these the trains operate with significant numbers of standees. This is in part a result of the shift in commuter patterns that occurred following the September 11 shutdown of the PATH service to lower Manhattan. However, a longer-term growth trend in trans-Hudson commuting coupled with capacity restrictions on the number and length of trains on the routes into New York's Penn Station has resulted in continuing increases in load factors on the trains.

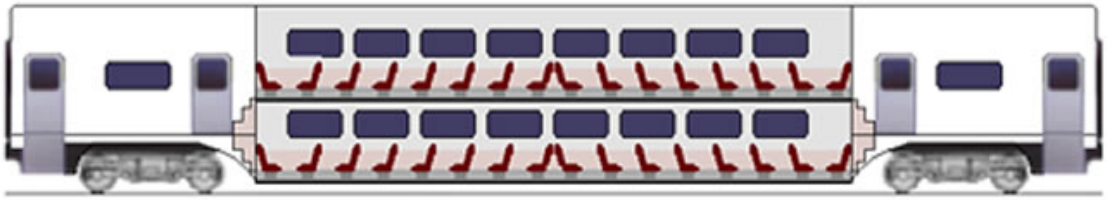
Figure 1: NJ Transit Commuter Rail Service

To address the capacity issues, NJ Transit initiated a study of multi-level coaches. A custom coach design is required to deal with geometric restrictions in the Hudson River tunnel and much of the early work involved the development of a workable multi-level concept design. The current concept is a multi-level design with mezzanine, upper and lower levels. The mezzanine is the platform entrance level and it has handicapped seating, other flip-down

side seating and room for standees. The upper level has 3-2 seating and the narrower (because of tunnel restrictions) lower level has 2-2 seating. Figure 2 is a sketch of the current concept.

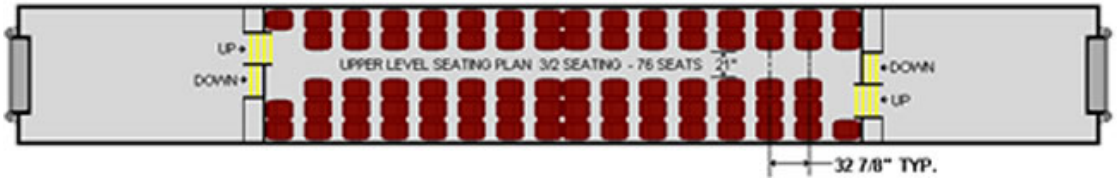
Figure 2: NJ Transit Multilevel Coach Concept

Side View



Lower Level

Upper Level



Before finalizing the concept, NJ Transit decided to conduct detailed customer research to provide guidance on some of the interior design details and to determine the overall customer reaction to multilevel coaches. This research was conducted over a two-month period in spring, 2002.

STUDY DESIGN

The customer research was designed to capture both qualitative and quantitative information. The qualitative portion of the research was structured as a set of focus groups, followed by a product clinic. The quantitative research was conducted using a detailed computer-based questionnaire.

STUDY SAMPLE AND LOCATION

NJ Transit train riders on the Northeast Corridor, New Jersey Coast, M&E, and Raritan Valley train lines were recruited for the focus groups and quantitative survey from NJ Transit's database of customers who had participated in NJ Transit's 1999 Rail Customer Satisfaction Survey. The sample was chosen so that the station boarding locations and peak/off-peak distributions matched existing ridership.

Focus Groups and Product Clinics

A total of 16 focus groups (144 total participants) and product clinics were conducted, consisting of four groups for each of the four lines serving trips for which multilevel coaches will be provided. These include the three lines that provide direct service into New York City (North Jersey Coast Line, Northeast Corridor) as well as passengers from the Raritan Valley Line who transfer at Newark. The focus groups covered general issues related to current service conditions and seating preferences, perceptions of the current Comet-series passenger coaches and detailed reactions to the multi-level concepts. The product clinics included six different seat designs that were being considered for the new coaches and customers were asked to try each seat, rank the seats in order of overall comfort and provide comments on the seat designs.

Quantitative Research

A computer-based survey questionnaire was developed that covered the same set issues as the focus groups and product clinics. The questionnaire began by asking respondents to indicate the NJ Transit line on which they travel. Respondents from each of the four study lines were evenly assigned into two groups; an inbound group and an outbound group. The questionnaire used a parallel design for the two respondent groups but questions were

customized for differences between the groups and for specific trip characteristics within the respondent groups. Respondents selected their origin and destination stations by clicking their boarding and deboarding stations on an interactive line map. The questionnaire collected information about respondents' one-way trip using the NJ Transit rail system; asking about details such as fare, ticket type, method of ticket purchase, the time of travel, trip purpose, and the frequency with which they make their one-way trip. Additional trip information included their perceptions of how crowded their coach was and whether they changed their travel times and/or station to avoid crowding.

The core part of the questionnaire was a section in which respondents made trade-offs among hypothetical service conditions, with reference to their current commuting trip. The wording of the questions was customized for inbound and outbound trips and train lines. Answer choices and instructions were also customized based on respondent type or responses to previous questions. This section used a conjoint analysis approach to measure preferences among multi-level coaches features. Conjoint analysis is a behavioral research technique in which respondents trade-off levels of attributes so that the relative importance, or utility, of the attributes and levels can be determined. There are different types of conjoint analysis and variations on the implementation of the concepts. For this study, Adaptive Conjoint Analysis ("ACA") was used.

ACA was developed in the 1980s as a market research tool to estimate consumer preferences among large numbers of product features ("attributes") than could be evaluated using previously developed conjoint methods (Sawtooth, 2002). ACA is a computer-based method that statistically estimates each respondent's preferences as the survey progresses and "adapts" the questions in a way that allows the effects of the many features to be measured. Because of the way that the data are collected, the preferences can be modeled and analyzed at the individual customer level. ACA is a useful tool for developing information about the relative preferences among many features such as the many features of a multi-level coach. The approach has been used for a number of past transportation-related projects (see, for example, Richardson, 2002; Falzarano, et al, 2001).

The survey questionnaire that was developed for this study used ACA to measure respondents' relative preferences among ten transit related features and their respective levels that were selected for analysis (Table 1).

Table 1: Transit features and levels measured in ACA section

TRANSIT FEATURES	LEVELS
FARE	fare minus 10% fare minus 5% fare same as current fare plus 5% fare plus 10%
FREQUENCY	2 more trains per hour same number of trains per hour 2 fewer trains per hour
IN-VEHICLE TRAVEL TIME	trip takes 4 minutes less trip takes 2 minutes less trip takes 2 minutes longer trip takes 4 minutes longer
SEAT MATERIAL	vinyl seating material cloth seating material
TRAIN TYPE	multi-level train single-level train
SEATING DIRECTION	transverse seating (subway style) reversible seating (center aisle, seats flipped forward or reverse as preferred) fixed seating (center aisle, half facing forward, half backward)
SYSTEM SEATING CAPACITY	45% more seats on your line 25% more seats on your line same number of seats on your line
OVERHEAD RACKS	overhead rack can fit a large suitcase overhead rack can fit a briefcase no overhead rack
SEATING COMFORT	comfort equivalent to seat A comfort equivalent to seat B comfort equivalent to seat C comfort equivalent to seat D comfort equivalent to seat E comfort equivalent to seat F
SEATING LOCATION	stand in aisle on upper or lower level stand in entryway sit in center seat of three-across (other two occupied) sit in aisle or window seat of three-across (other two occupied) sit in aisle or window seat of three-across (center unoccupied) sit in aisle or window seat of two-across (other occupied)

The ACA approach for this study included three parts. First, the rank order of the levels within each attribute was determined (Figure 3). Rank ordering is especially important for applications such as this one where the order of preferences varies across customers. Second, the best and worst levels of each attribute were displayed and the respondent indicated on a five-point scale the importance of obtaining the preferred level of that attribute (Figure 4). This rating information is used to determine the importance of one attribute relative to another for each individual

respondent. Third, a series of pair-wise trade-off scenarios were presented with two or three attributes shown at a time (Figure 5). In each scenario, respondents were asked to choose between a highly valued level of one attribute and a highly valued level of another attribute. Each highly valued level is paired with a less preferred level of the other attribute. Respondents use a nine-point scale to indicate the pair they prefer and the strength of their preference. Each pair-wise trade-off question is customized using a respondent's answers to previous questions.

Figure 3: ACA Screen - Rank Order

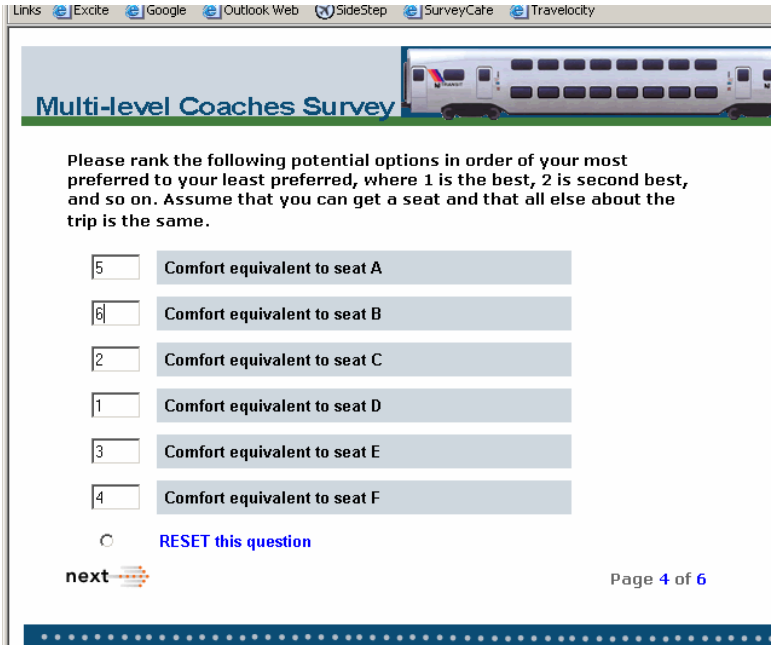


Figure 4: ACA Screen - Rate

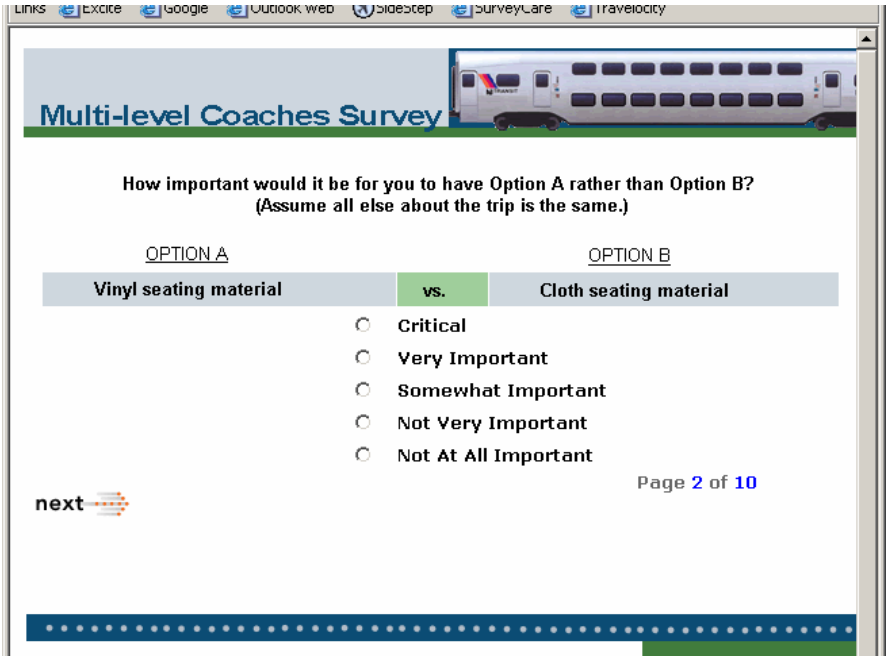
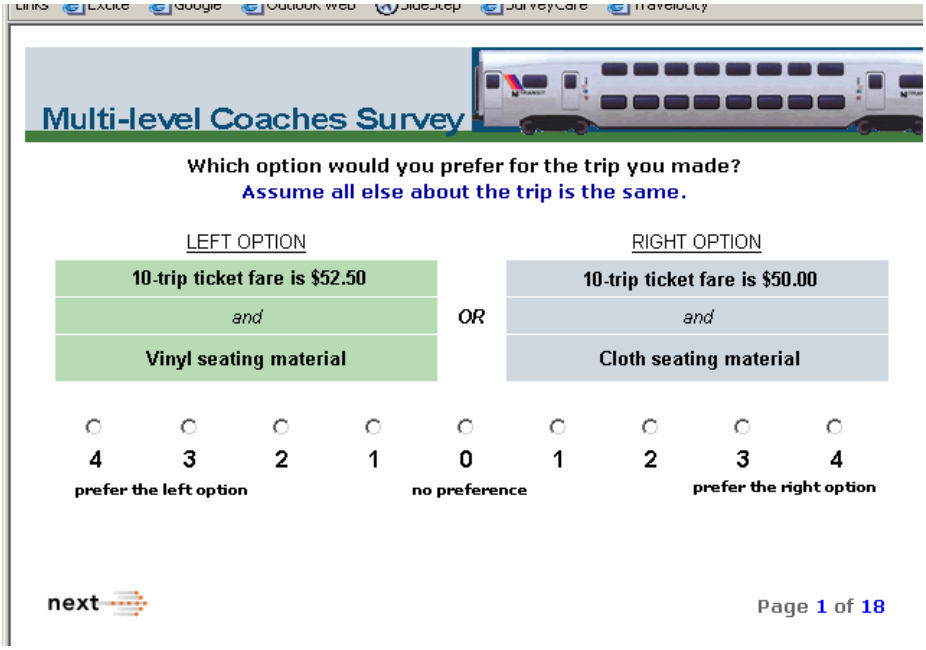


Figure 5: ACA Screen - Trade Off



FOCUS GROUP AND PRODUCT CLINIC FINDINGS

The focus groups covered a number of topics related to general and line-specific service issues. Overall, participants clearly indicated that crowding in general and lack of adequate seating capacity in particular were significant problems during peak periods. The capacity deficiency has resulted in many customers simply accepting standee status, though they expressed hope that there would be changes to increase capacity. Other customers have changed their travel behavior in ways that give them a better chance of boarding a train with available seats. And yet others have developed strategies for increasing their chances of getting a seat on a given train. Table 2 lists the most frequently-cited adaptive strategies.

Table 2: Reported methods of 'Getting a seat'

Ways of avoiding crowded trains to get a seat	Ways of getting a seat on a crowded train
1. Taking an earlier or later train.	1. Using the middle seat even if it requires being assertive with the people in the aisle and window seats.
2. Boarding at a station that is further out (further away from Penn Station New York).	2. Getting to the station early enough to be on the right track before the boarding call is made.
3. Changing trains at Newark to or from the PATH/Hoboken.	3. Boarding the end car and working the way up until you find a seat.
	4. Waiting for someone to get off in Newark to get his or her seat before Newark boarders get on. This is done by savvy riders checking ticket stubs to see who will be departing at Newark.

Participants reacted favorably overall to the multilevel coach concept. They liked having a choice of seat location (upper, lower, mezzanine) and seat configuration (2-2, 3-2). The only concern that was expressed with any frequency related to internal circulation issues and possible increases in dwell time that might be required to board or discharge the larger numbers of passengers on the cars.

In the product clinic, participants were asked to try each of six different seat designs (Table 1). Each design included one seat with cloth and one seat with vinyl fabric. Two of the seats designs were clearly favored over the other four. These designs were different from the current Comet coach seating in several respects, including more defined contouring. A summary of the reactions to these seat options is given in Table 3.

Table 3: Seat Types Tested

Seat A –TMS Stationary - Short Seat Taller back, can't be flipped

Seat B – TMS Walkover - Short Seat, somewhat shorter back, can be flipped

Seat C – USSC Walkover - Newer style, can be flipped

Seat D –USSC Fixed - Airline style, movable armrests, can't be flipped

Seat E – USSC Walkover - Comet V

Seat F – Coach and Car Walkover - Comet IV

Table 4: Qualitative Seat Likes and Dislikes

LIKES	DISLIKES
1. Seats C and D were consistently chosen for overall comfort by the majority of participants	1. Firm or hard seats
2. Armrests, especially movable ones	2. Narrow seats
3. Large sturdy standee handles	3. Straight back seats
4. Clear definition of your seat: "I like it to be clear that this is **my** 19", this is my space."	4. Short seat cushion

Participants had decidedly mixed reaction to the seat covering material. Some preferred vinyl because it is less likely to be stained and is easier to slide across. They were concerned that cloth seats could not be adequately cleaned given the short times between runs on the commuter railroad. Others preferred the look and feel of cloth fabrics and felt that adequate cleaning could be managed.

QUANTITATIVE RESEARCH FINDINGS

The primary purpose of the study was to determine how changes in transit coaches from single-level to multi-level will affect the overall benefit that NJ Transit riders derive from their train trips. To achieve this goal, the analyses were distilled to the following summary measures:

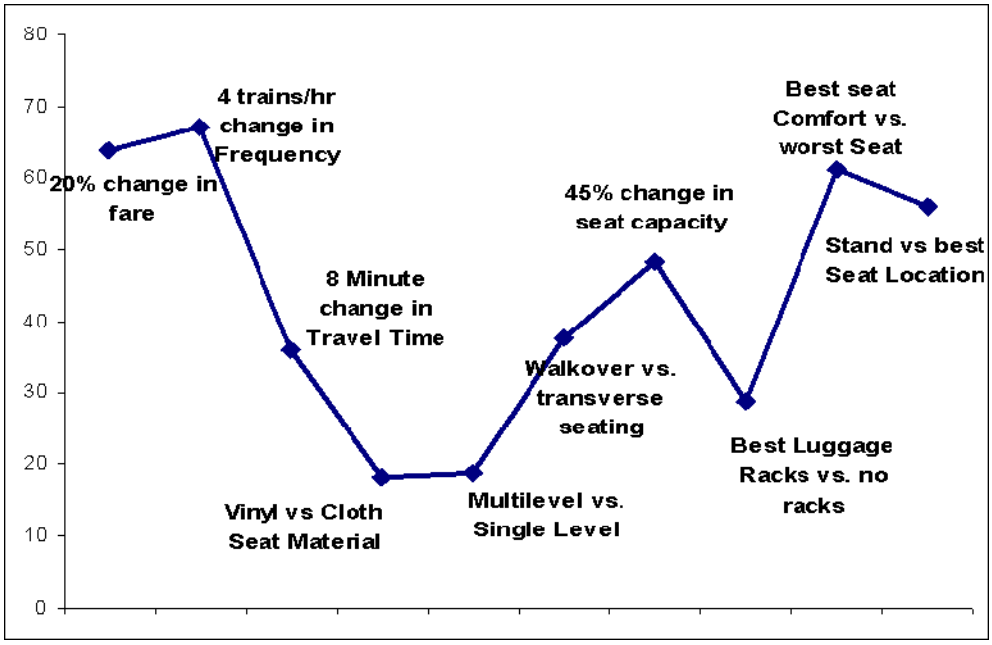
- Importance scores of attributes relative to all other attributes
- Utility values for each study attribute and its levels within the attribute
- Attribute bundle for multi-level coaches that produce the most value for NJ Transit customers

Based on these results, conclusions and recommendations on how to proceed with the procurement and operation of multi-level coaches were developed.

Importance Scores

Conjoint analysis enables attributes to be placed on an importance scale relative to each other. This provides an understanding not only what is most preferred compared to something else, but also the strength of the preference.

Figure 6--Importance scores



As shown in Figure 6 above, core service attributes (fare, service frequency, travel time) are used as baseline variables against which to compare the other attributes. These other attributes can then be evaluated compared to those service attributes and/or to each other. For example, the statistical analyses of ACA data indicate that respondents place an importance score on getting the most comfortable seat design compared to the least comfortable design almost equal to that of a 20% fare difference. This means that they are willing, on average to pay 20% higher fares to get that seat as compared to getting the seat type which they judged to be the least comfortable. Similarly, they are willing to pay almost as much to get a seat in their most preferred location compared to standing. A separate capacity attribute is included because the increase in seat capacity has utility to customers beyond simply increasing customers' chances of getting a seat; less crowding translates to more comfortable conditions overall in the coach. Its value is lower than the seating attributes, but still significant.

The multilevel attribute measures the benefit that customers derive from the additional seating choices provided on multilevel coaches. This benefit is small compared to the effects of seating comfort, capacity and crowding improvements, but is consistently positive across the respondents. By contrast, the values for vinyl vs. cloth are both low and mixed across respondents; some prefer cloth, some prefer vinyl and overall the strengths of those preferences are low.

It should be noted again that the importance scores are relative to one another. For example, Figure 6 does not indicate that frequency and fare are more important than travel time in general. Instead, it needs to be interpreted very specifically: an eight minute swing in travel time has roughly half the importance to respondents as a four-train-per-hour change in frequency. This appears reasonable, as a four-trains-per-hour change in frequency can be very large (e.g., two trains per hour vs. six trains per hour), while an eight minute travel time change was felt by respondents to have roughly half that importance.

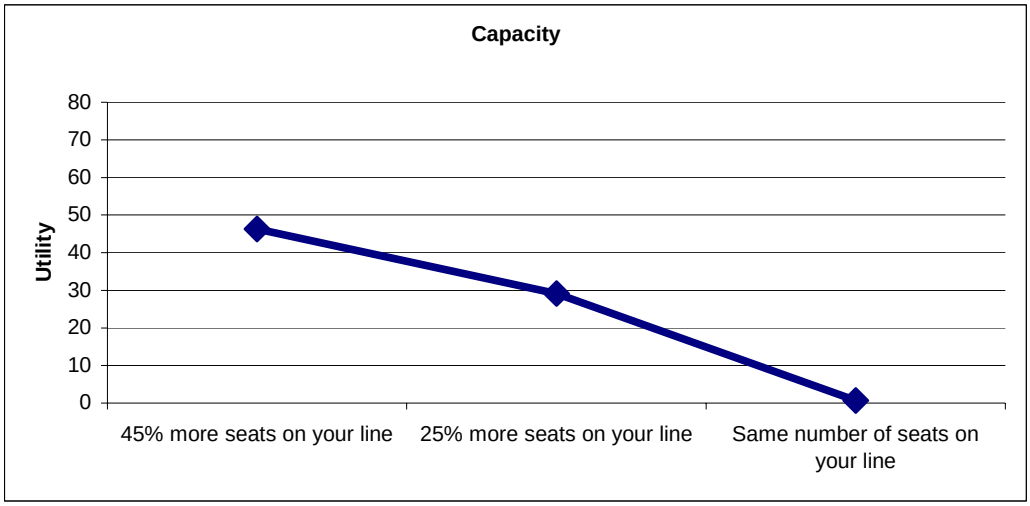
Attribute Utility Values

For each attribute shown in Table 1 and Figure 6, the values of the utility for each "level" of the attribute is calculated using conjoint analysis, providing information about the relative attractiveness of each level of each attribute. In addition, the values for selected attribute levels were calculated relative to the fare attribute to get a "willingness to pay" benefit measure. The sections that follow describe in more detail the effects of each of these features.

Seating Capacity

Capacity is obviously an issue for travelers who do not get a seat. However, even those respondents who reported getting a seat on their commute indicated a relatively high utility for capacity, the more seating space the more utility for respondents (Figure 7).

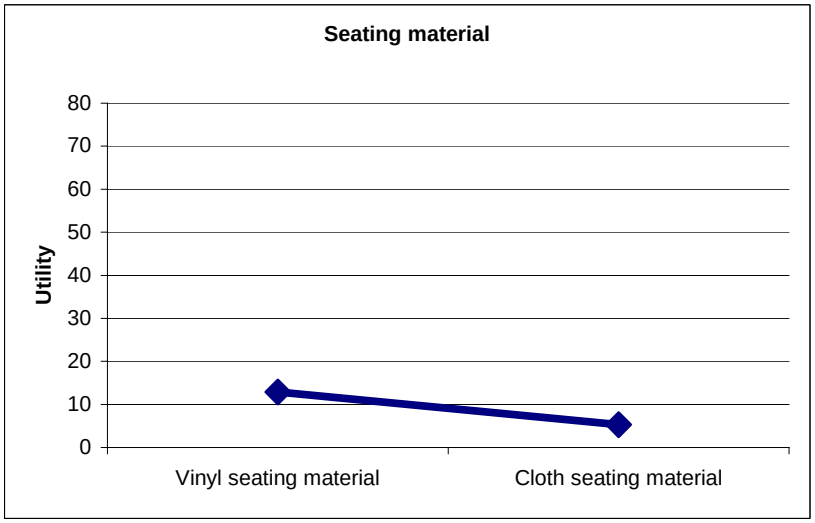
Figure 7: Seating capacity preferences



Seating Material

On average, rail customers value vinyl seat material slightly over cloth (Figure 8). Focus group discussion indicates that, although customers generally agree that cloth is more comfortable, many are more concerned with cleanliness and durability over actual material. Overall, seating material was not an important issue to respondents.

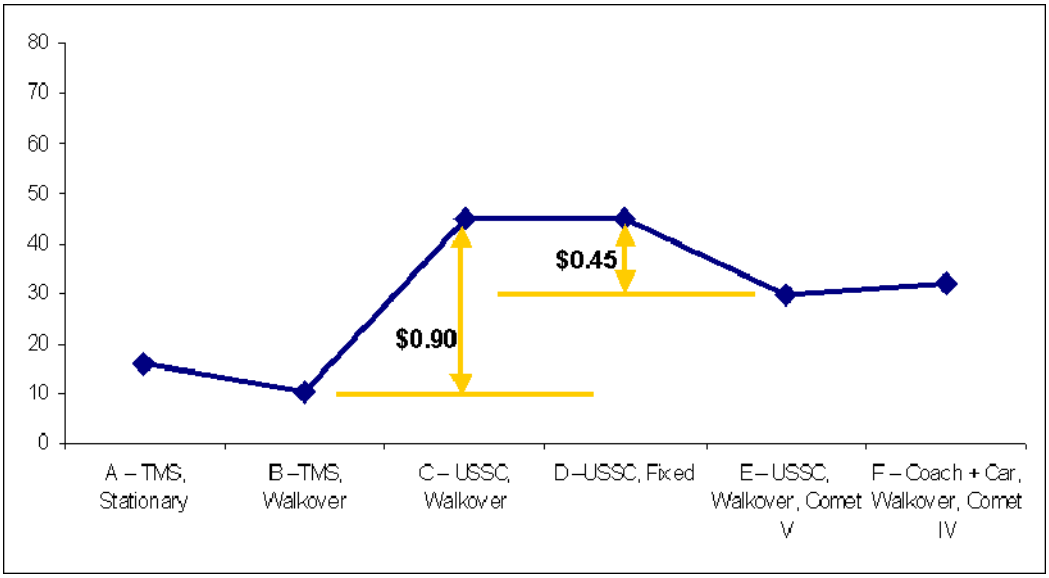
Figure 8: Seating material preferences



Seating Comfort

Respondents indicated a clear preference for seat comfort equivalent to seats C and D, placing a value on them of $0.90 over seat B. The seats currently found in NJ Transit coaches, seats E and F, were preferred over seats A and B by a value of approximately $0.45 (Figure 9).

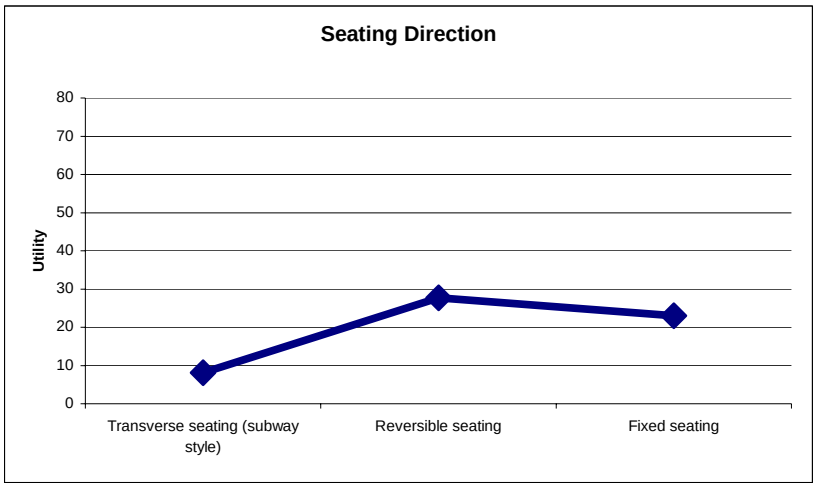
Figure 9: Seating comfort preferences



Seating Direction

Consistent with focus group discussion, respondents prefer reversible seating slightly to fixed seating (Figure 10). During the focus group discussion, respondents indicated by a show of hands that, although they prefer the option to flip their seats to face the direction of travel, most would be likely to sit in a fixed seat facing backwards as opposed to standing. The reversible and fixed seating is clearly preferred over transverse seating, consistent with respondents emphasis on increasing seating capacity and comfort on the coaches.

Figure 10: Seating direction preferences



Seating location

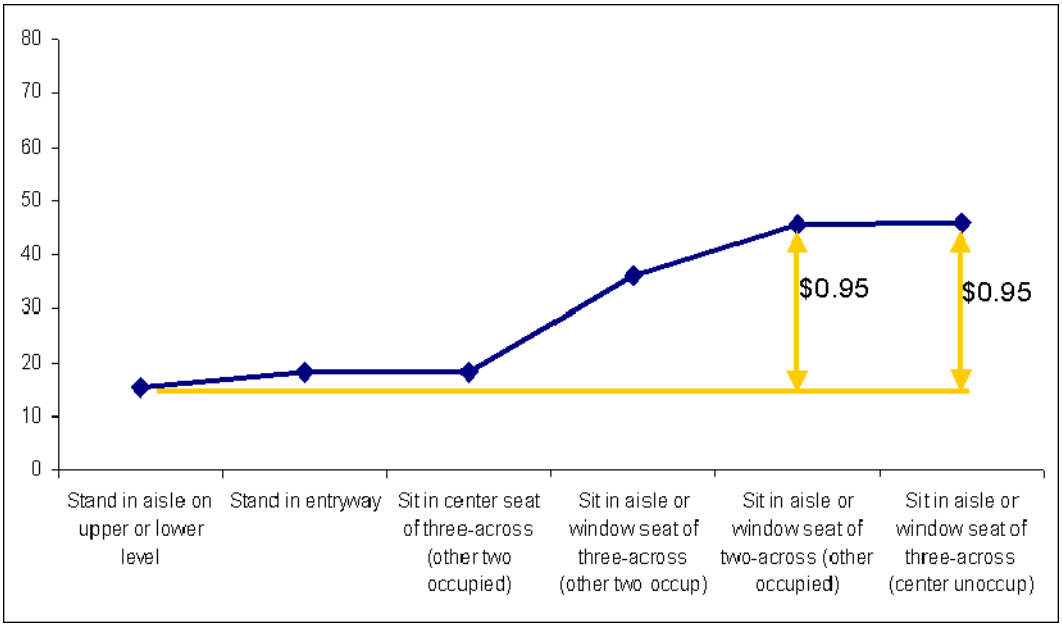
This study found that sitting in the middle of a 3 across row is not much different from standing. Clearly, a seat at a window or aisle strongly improves utility for customers. A value of $0.95 is placed on sitting in the aisle or window seat of a two across or sitting in the aisle or window seat of a three across with center seat unoccupied (Figure 11). The seat location attribute is important to customers overall.

The question of whether 2-2 seating is preferred over 2-3 seating and by how much was not directly answered in this study. The widths of all seats evaluated in this study were the same, no matter whether they had a 2-2 seat or a 2-3 seat configuration.

However, information on the strength of preference for seating configurations gives some important understanding of at least some of the differences between 2-2 and 2-3 seating configurations. The utility is essentially the same for a 2-2 configuration where both seats are occupied versus a 2-3 configuration where the middle seat is unoccupied, with both configurations having the same seat widths (Figure 11).

A more comprehensive study focusing on 3-2 versus 2-2 seating was conducted in 1995 by NJ Transit. The 1995 study found somewhat different results than this Multilevel study. The 1995 study showed riders most prefer a 3-2 window or aisle seat, assuming the middle seat is unoccupied, versus a 2-2 configuration when both seats are occupied. As described above, these options were found to be equivalent in this Multilevel study. The 1995 study also indicated that customers prefer to sit in the middle seat of a three across versus standing. This study had the same finding; however, it was not a significant increase in utility as it was in 1995.

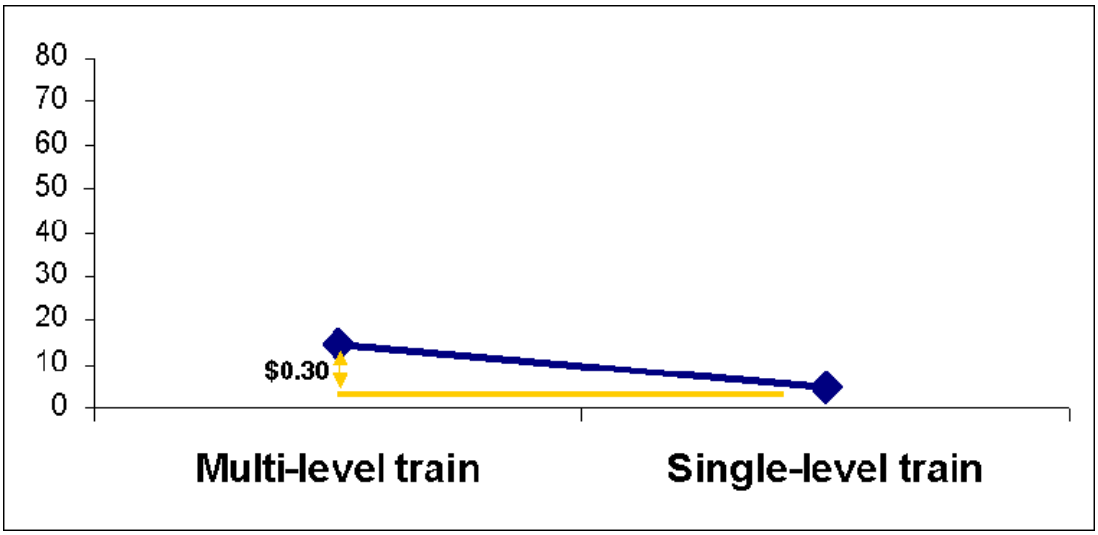
Figure 11: Seating location preferences



Train Type

The multi-level train type was preferred to the single-level train, but only slightly. Customers place a value of $0.30 on the multi-level train type over the single-level train type. Train type was not that important to customers overall (Figure 12).

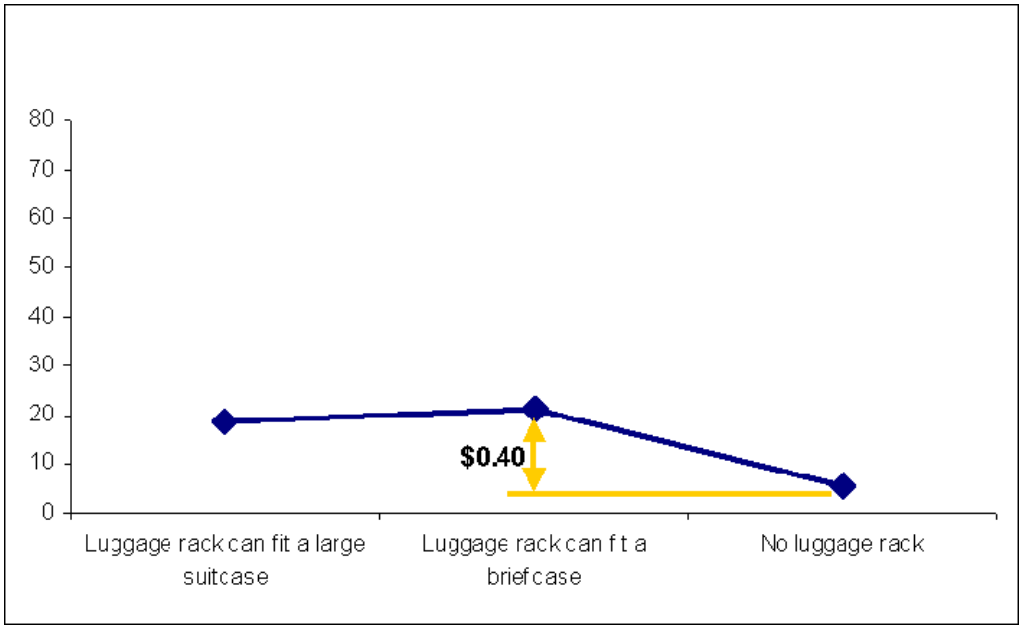
Figure 12: Train type preferences



Overhead Racks

A place to put a briefcase or a coat is what customers prefer most, with a value of $0.40 over no overhead rack. A briefcase rack is valued only slightly higher than a larger overhead rack. Although the issue of airport luggage was an active topic during focus group discussion, large racks are not preferred (Figure 13). This may be due to the perception that regular customers would rather not have people lifting large bags onto overhead racks because it is thought of as difficult, disruptive, and potentially dangerous.

Figure 13: Overhead rack preferences

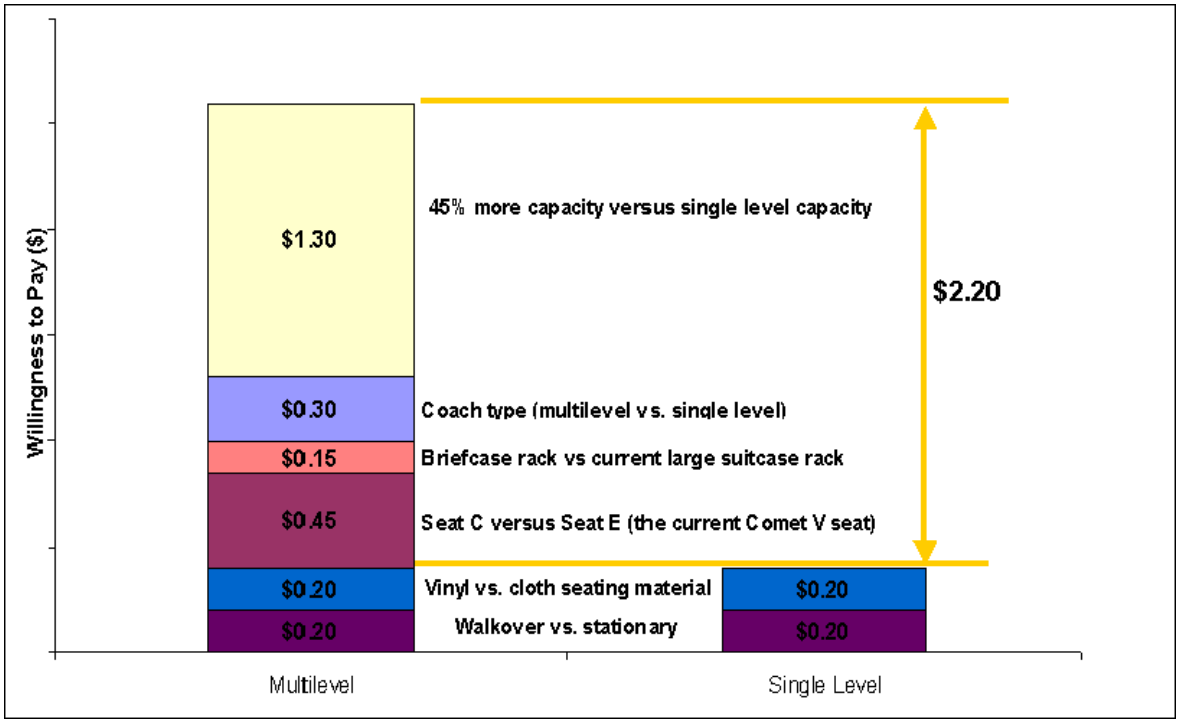


Multi-level Attribute Utility Bundle

As seen in many of the charts above, conjoint analysis enables a “willingness to pay” value to be calculated on each level of each attribute in the study, based on how respondents answered between the fare attribute and all the other

attributes. The higher the utility, typically the higher the "willingness to pay." However, it should be noted that wealthier individuals may be more willing to pay for an attribute they prefer than those with less money. Therefore, the magnitude of the willingness to pay may not correlate in a one-to-one ratio to the magnitude of utility.
Based on the willingness to pay calculations, we derived an optimal "bundle" to use to configure the new multi-level coaches (Figure 14).

Figure 14--Multi-level bundle compared to existing Comet V coach



The conjoint analysis indicates that riders place an overall value of $2.60 on the full multi-level coach bundle, which includes 45% more capacity than single-level coaches, increased value due to the preference of multi-level coaches in and of themselves over single-level coaches, briefcase-sized overhead racks versus the single-level large overhead racks, seat C versus the current single-level Comet V's seat E, vinyl versus cloth seat material, and walkover versus stationary seating. This bundle adds $2.20 worth of value over the current single-level trains, as both the multi-level trains and the single-level train share vinyl and walkover seating attributes. This $2.20 value is a significant increase in consumer surplus to NJ Transit rail customers because fares will not go up due to the introduction of multi-level trains. Therefore, the effect of having the optimal multi-level bundle will give NJ Transit customers an extra $2.20 per one-way trip in value without having to spend any more than they currently do.

The most value derived from the multi-level coaches is by far due to seating capacity ($1.30/trip). This is no great surprise, as crowding is currently a major issue. NJ Transit customers place a high value on relieving this crowding with more seats. Furthermore, improving the quality of seating comfort adds significant value to customers.

CONCLUSIONS

This study found that providing additional seated capacity in the configuration preferred by customers provides a substantial net benefit to NJ Transit's passengers: equivalent to about $2.20 fare value per trip. The benefits are higher for this situation because of the degree of crowding that currently exists on these trains, but the study suggests that multilevel coaches and improved interior design have benefits well beyond the capacity increase that they provide.

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