Evaluating a Large Number of Station and Alignment Alternatives

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A novel three-step evaluation process was used to select the final alignment, station locations, and construction method for the Maryland Mass Transit Administration's rail transit extension into northeast Baltimore. During preliminary engineering of this subway line, known as Section C, several station box locations for two stations, numerous route alignments, and two tunnel construction techniques resulted in 24 alternative designs for the extension. Over a dozen evaluation categories, many with multiple criteria, had to be addressed including cost, patron access, constructability, environmental and community impacts, and joint development potential. A conventional evaluation matrix was not a practical nor appropriate means to select the best option. The evaluation procedure used had three steps—the first of which was a construction methodology evaluation conducted within a capital cost threshold established by a financing cap. Then, individual components that made up the alternatives, such as a station location, were evaluated to determine the best-to-worst ranking against the relevant criteria. The alternatives that included the most top-ranked components were then evaluated using a focused display matrix that included only those criteria that distinguished the remaining alternatives. This procedure, which was successful in identifying the plan for the extension now under construction, provides a practical means enabling engineers, architects, planners, operators, and policy makers to manage a large number of alternatives and evaluation criteria.

When the number of alternatives and evaluation criteria exceeded the practicability of a conventional evaluation matrix, an innovative three-step evaluation procedure was developed and successfully applied. The procedure demonstrates that a complex set of alternatives can be evaluated by disaggregating the alternatives into components and focusing on the distinguishing features among the alternatives rather than the absolute measures. The procedure reduces the number of alternatives and criteria to a manageable number that can be handled by more conventional evaluation techniques.

Section C of the Baltimore Metro will extend service from downtown at Charles Center into the northeast section of the city to the Johns Hopkins Hospital medical center. The extension will be about 1.5 mi in length and will include two stations—one called Shot Tower/Market Place on the eastern side of Baltimore's central business district, and one at Johns Hopkins Hospital, a major employment center. All the facilities for the extension to Johns Hopkins Hospital are underground, through an area that was part of the early settlement area of Baltimore. Subsurface features include water-saturated soils, areas where the harbor was filled, old and modern utilities (including a conduit built in 1910 that carries the Jones Falls stream), and potential archaeological features. The extension, consisting of twin circular tunnel trackways driven partially with compressed air, is now in construction. The stations will both be built by cut-and-cover methods, i.e., open excavation from the surface.

At the end of the UMTA Alternatives Analysis/Draft Environmental Impact Statement (AA/DEIS) process for the rail transit project, the alternative extending from the present metro terminus at the Charles Center Station under Baltimore Street, continuing eastward below Fayette Street, and subsequently northward under Broadway to a new terminus at Johns Hopkins Hospital, was selected as the preferred alternative (see Figure 1). Several variations of the preferred alternative merited further investigation during the preliminary engineering/final environmental impact statement (PE/FEIS) phase of the project. Design options that were to be evaluated and refined during PE/FEIS included alignments below either Baltimore Street or Fayette Street; shallow or deep profiles; cut-and-cover construction instead of shield-driven, soft-ground, and rock tunneling; variations in the location of stations and station entrances; rail-bus transfer facilities; and other possible changes in the then-defined characteristics of the preferred alternative.

The initial phase of the PE/FEIS consisted of an evaluation of alternatives leading to a recommendation for the design alternative to be chosen for advancement into preliminary design. The process was used to evaluate alternative alignment and station options and construction methodologies.

BASIC BUILDING BLOCKS

The set of alternatives for the Metro Extension resulted from the combination of various station locations, crossovers, alignments, and different methods of construction. A total of 24 possible alternatives were defined. A traditional evaluation process that would compare this set of 24 alternatives was determined to be too cumbersome, and, more important, individual differentiating factors relative to station locations and construction methodology tended to be overshadowed by alignment issues.

Because the alternatives were defined by stations and crossover locations, alignments, and construction methods, a basic building block approach was applied for comparing the components. The individual components that make up each alternative were assessed individually to arrive at the preferred option. The components were termed

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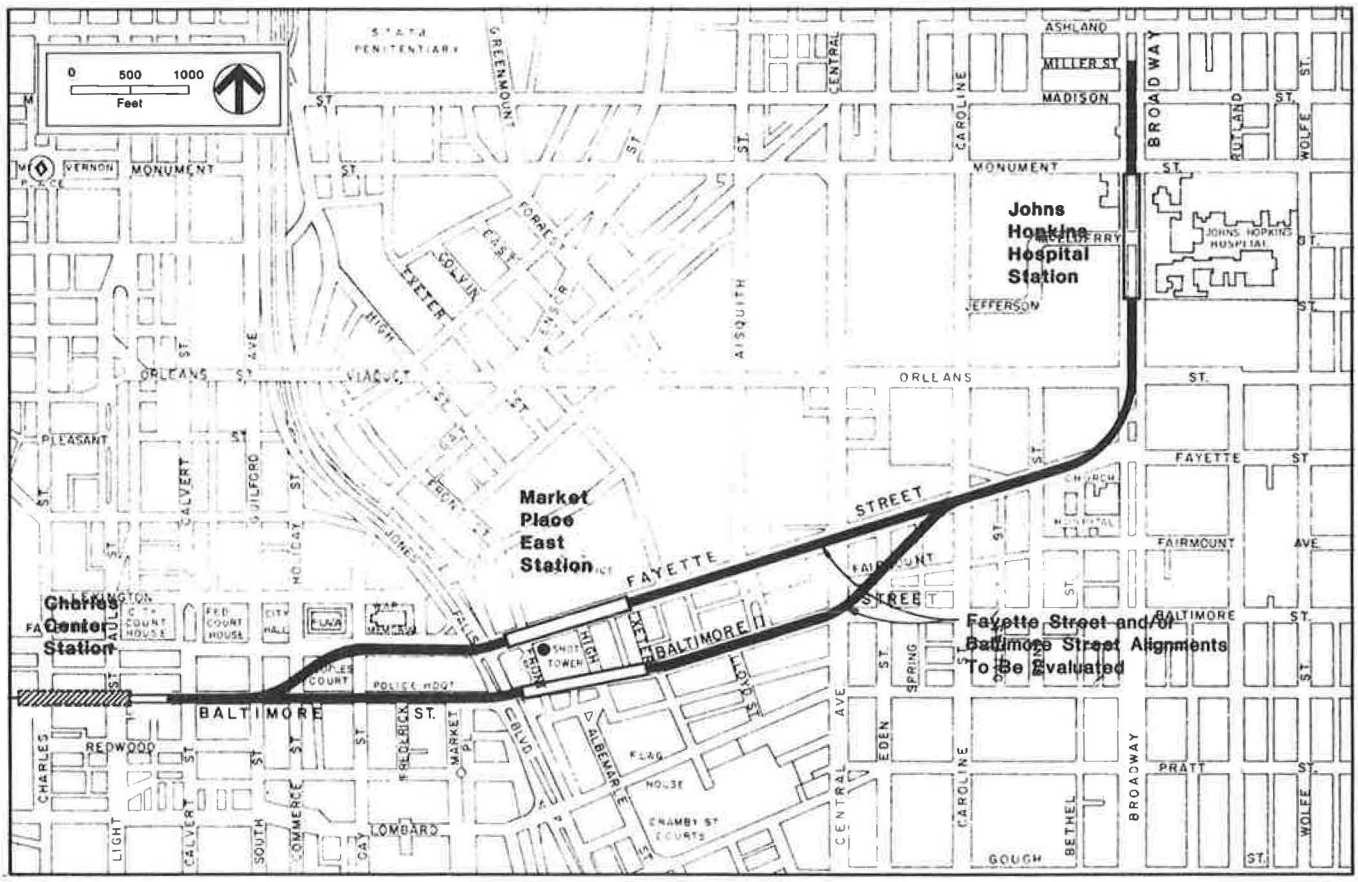

FIGURE 1 Preferred alignment—AA/DEIS.

• *Conditions.* Refers to station locations and related crossover variations. There are nine conditions, five at Shot Tower/Market Place and four at Johns Hopkins Hospital. Some station locations, especially at Shot Tower/Market Place, are only possible with certain alignment options.

• *Alignments.* There are four alignment variations, one on Fayette Street, one on Baltimore Street, and two alternatives that transition from Baltimore Street to Fayette Street at different locations.

• *Construction Methodology.* Refers to the mix and extent of cut-and-cover construction and tunneling.

The nine station conditions are as follows:

• *Shot Tower/Market Place*

—Condition 1: West of the Jones Falls Boulevard under Baltimore Street.

—Condition 2: Straddling the Jones Falls Boulevard under Baltimore Street.

—Condition 3: East of the Jones Falls Boulevard under Baltimore Street.

—Condition 4: East of the Jones Falls Boulevard under private property, diagonally between Baltimore and Fayette Streets.

—Condition 5: Underground station east of the Jones Falls Boulevard, in Fayette Street.

• *Johns Hopkins Hospital Station* (all under Broadway with tailtrack immediately north of platform)

—Condition 6: North oriented with direct connection to the north bus transfer facility. No. 10 crossover immediately south of platform.

—Condition 7: More southerly oriented than Condition 6, indirect connection to north bus transfer facility. No. 15 crossover located on Fayette Street west of curve.

—Condition 8: Same platform location as Condition 7, with direct connection to north bus transfer facility and hospital development. No crossover immediately south of platform.

—Condition 9: Most southerly oriented station location, with direct connection to south bus transfer facility and hospital development. No. 10 crossover immediately south of platform.

The four alignment variations all start under Baltimore Street at the existing Charles Center Station. They are summarized below:

• *Alignment I.* A Fayette Street alignment that transitions from Baltimore Street to Fayette Street near Gay Street, and then curves over to Broadway, north of Orleans Street. A refined version of the Fayette Street alignment shown in the AA/DEIS.

- *Alignment II.* A Baltimore Street and Fayette Street alignment that transitions to Fayette Street at about Eden Street, and then curves over to Broadway, north of Orleans Street (same as Alignment I). This alignment is a refined version of the Baltimore Street alignment shown in the AA/DEIS.
- *Alignment III.* A Baltimore Street alignment, continues under Baltimore Street all the way to a block east of Caroline Street where it curves over to Broadway at a point just south of Fayette Street. (Does not follow Fayette Street at all.)
- *Alignment IV.* A variation of Alignment II that stays under Baltimore Street only as far as the Jones Falls Boulevard where it curves up to Fayette Street, and then curves over to Broadway north of Orleans Street (same in this section as in Alignments I and II).

The combination of variations in conditions, alignments, and construction methodologies resulted in 24 alternatives that were evaluated by this process. These alternatives, perhaps better designated as "design options," are really design variations of the recommended scheme that are out of the AA/DEIS process. However, for the purpose of this evaluation the 24 design options are designated as shown in the matrix of Figure 2.

OUTLINE OF THE PROCESS

The evaluation was conducted in three steps. In the first step, comparative costs for each alternative were reviewed to determine if a significant cost saving could be realized by cut-and-cover construction versus tunneling for the alignments. The evaluation was performed within the context of a capital financing cap established by the amount of funds available from an Interstate transfer.

In the second step, the components that make up the alternatives (conditions and alignments) were assessed against measures that reflect the key factors and issues at each station area and along the alignment. The information was presented in a simple matrix with a relative rating given to the condition or alignment for each evaluation measure. The measures fell under seven major headings that best distinguished significant differences among the station conditions and alignments. To summarize the evaluation, an overall preferred

Alignment	Alternative Description	Station Condition		Line Structure Construction Features						
				West of Jones Falls Blvd		East of Jones Falls Blvd			Curve in Broad	
		Market Place	Johns Hopkins	Tunnel	Cut & Cover	Tunnel	Cut & Cover	#15 Crossover	Tunnel	Cut & Cover
Fayette (Alignment I)	I.	5	6	■		■			■	
	I.A.	5	7	■		■		■	■	
	I.A.1.	5	7	■			■	■		■
	I.A.2.	5	7	■			■	■	■	
Baltimore (Alignment II)	II.	1	6	■		■			■	
	II.A.	2	6	■		■			■	
	II.B.	3	6	■		■			■	
	II.C.	1	7	■		■		■	■	
	II.C.1.	1	7		■		■	■		■
	II.D.	2	7	■		■		■	■	
	II.D.1	2	7		■		■	■		■
	II.E.	3	7	■		■		■	■	
Baltimore/Broadway (Alignment III)	III.	1	8	■		■			■	
	III.A.	2	8	■		■			■	
	III.A.1.	2	8	■			■		■	
	III.B.	3	8	■		■			■	
	III.C.	1	9	■		■			■	
	III.D.	2	9	■		■			■	
	III.E.	3	9	■		■			■	
Baltimore/Fayette (Alignment IV)	IV.	1	6	■		■			■	
	IV.A.	4	6	■		■			■	
	IV.B.	1	7	■		■		■	■	
	IV.C.	4	7	■		■		■	■	
	IV.C.1.	4	7	■			■	■		■

FIGURE 2 Alternatives description matrix.

assessment rating was given to those conditions and alignments that were clearly better. Once this step was completed, the over-all assessment was carried over to Step 3 (Alternatives Assessment).

In the third step, the preferred conditions and alignments were entered into a second matrix that listed all of the remaining alternatives. Because each alternative comprised various station conditions and alignments, this step involved identifying the alternatives that included the greatest number of preferred conditions and alignments. By this process, the alternatives that did not include preferred conditions or alignments were quickly eliminated and an overall preferred alternative (or alternatives) was identified. If a clear choice did not emerge from the second matrix, further evaluations could proceed with the most promising alternatives identified at that point.

Step 1: Comparative Costs for Construction Methods

As part of the process leading to an evaluation of each of the defined alternatives, the need for comparative cost estimates was determined. It was anticipated that there might be significant differences in construction and right-of-way costs between the set of alternatives that involved driven tunnels and those that employed cut-and-cover construction for the line sections, and that these differences might offset other advantages and disadvantages that could be attributed to an alternate. For the purpose of this examination, the cost estimating would only involve those elements that were unique to each alternative, and those elements that were common to all would be excluded at this time. It was also established at this time that the total project had a $300 million (1986 dollars) funding cap and any alternative that exceeded that amount would be viewed as fatally flawed and eliminated from further evaluation.

The basic elements for each alternative estimate were the station structures and the specific line structure configuration for that alternative, which were developed around the horizontal and vertical alignments for each, and construction by a method determined by the site-specific geotechnical requirements at each location. It was assumed that all station structures would be constructed from the top down with cut-and-cover construction. The cost estimate for stations would include all structural elements and contractor's costs to build the station shell but would not include station finish or mechanical and electrical costs that would be essentially similar for all stations.

Both for driven tunnels and cut-and-cover construction, including applicable stations, provisions for underpinning or protection of existing buildings and structures were factored into the cost estimates on a site-specific basis for each alternative. Because all alternatives require passing under the Jones Falls conduit with differing construction methodologies (i.e., by driven tunnel, cut-and-cover, or cut-and-cover with a straddle station), cost estimates for each method were incorporated into the appropriate alternative.

As with station structures, these estimates only considered the structural elements for line structures and contractor's costs and did not include trackwork, traction power, train control and communications, and ventilation costs, which would be similar for all alternatives. In addition to the comparative construction costs for each alternative, preliminary right-of-way costs were developed for each alternative. The right-of-way cost estimate for each alternative, combined with the construction cost estimates, provides a total comparative cost estimate for each alternative.

The cost estimates are shown in Figure 3. An immediate and important conclusion was drawn from these estimates. Several alternatives were developed to specifically provide for cut-and-cover construction of line structures as an alternate for driven tunnels on the basis that such a construction technique might be materially less costly (although with significant surface disruptions and community impacts) and should therefore be given consideration. Taking into account the necessary factors relating to the costs for cut-and-cover construction for the specific alignments developed, the comparative construction costs clearly indicated that cut-and-cover construction was not less costly, but in fact was significantly more costly than the driven tunnel comparison alternative.

Because the reason for including such cut-and-cover alternatives was not borne out by the cost estimates, there was no justification for continuing to include those six alternatives in the ensuing evaluation of alternatives. Accordingly, that set was dropped from the list of potential alternatives for continued consideration.

Step 2: Component Assessment

Evaluation Measures—Alignments and Conditions

In Step 2 of the evaluation process, evaluation measures were reviewed and screened to include those key issues or factors that could be used to distinguish the significant differences among the various station conditions and alignments. Thus, issues that were more or less the same across all of the components were not included.

The measures fell into the following seven major headings:

- Constructability and cost
- Patronage and service
- Traffic impacts during construction
- Displacement and relocation
- Environmental impacts
- Community or agency concerns
- Private sector participation

Many of these headings included several distinct issues or factors, and those were treated separately. In the following paragraphs, each of the evaluation measures is discussed with the critical factors affecting the evaluation highlighted. In some cases, the measures were applicable only to the station conditions and not to the alignments.

Constructability and Cost

The constructability feature addressed the degree to which a construction project for either a station or alignment (tunnel) could be anticipated to proceed smoothly, on schedule and with little potential for additional costs due to delay, extensive

Alignment	Alternative Description	Station Condition		1986 Comparative Costs*		
		Market Place	Johns Hopkins	Construction	R.O.W.	Total
Fayette (Alignment I)	I.	5	6	97,918	1,950	99,868
	I.A.	5	7	98,934	1,950	100,884
	I.A.1.	5	7	113,942	3,460	117,402
	I.A.2.	5	7	104,695	1,950	106,645
Baltimore (Alignment II)	II.	1	6	97,517	1,170	98,687
	II.A.	2	6	97,856	1,170	99,026
	II.B.	3	6	100,290	1,170	101,460
	II.C.	1	7	98,064	1,170	99,234
	II.C.1.	1	7	125,819	4,300	130,119
	II.D.	2	7	98,406	1,170	99,576
	II.D.1	2	7	123,945	4,300	128,245
	II.E.	3	7	101,024	1,170	102,194
Baltimore/Broadway (Alignment III)	III.	1	8	101,724	1,010	102,734
	III.A.	2	8	101,566	1,010	102,576
	III.A.1.	2	8	118,025	1,010	119,035
	III.B.	3	8	105,595	1,010	106,605
	III.C.	1	9	99,206	855	100,061
	III.D.	2	9	98,367	855	99,222
	III.E.	3	9	102,394	855	103,249
Baltimore/Fayette (Alignment IV)	IV.	1	6	95,958	1,220	97,178
	IV.A.	4	6	96,849	2,770	99,619
	IV.B.	1	7	95,039	1,220	96,259
	IV.C.	4	7	98,213	2,770	100,983
	IV.C.1.	4	7	105,376	4,250	109,626

FIGURE 3 Comparative cost estimates.

change orders due to unforeseen field conditions, or contractor's claims. In effect, constructability was considered as a measure of risk inherent in the construction of any given alternative.

Although constructability would ultimately be reflected in cost, it would not be quantifiable at this point in the process and, therefore, needed to be considered as one of the measures for evaluating differences between alternatives. The cost measure was based on the comparative cost estimates for each alternative, as described previously. Engineering factors are reflected in the comparative cost estimates and were consequently addressed in this evaluation measure. The major variations in cost were attributable to the costs associated with station conditions rather than alignments, so the station cost issues dominated the assessments. Station depth, volume, maintenance of traffic (due to use of cut-and-cover construction for stations) and geotechnical concerns were major influences on station costs.

Patronage and Service Aspects

This category included issues concerned with the relative attractiveness, convenience, and safety for the users of the Metro extension, and the operations of the bus and rail transit services as follows:

Patronage. This measure reflected the attractiveness of a station condition to serve generators or attractors of transit trips. The travel demand model is relatively insensitive to minor variations caused by differing entrance locations in the same general area. A more judgmental approach was utilized in this analysis to supplement the travel model data.

Patron Convenience and Safety. This measure related to how well a station condition would serve the ridership in the surrounding market area. Real or perceived safety concerns were included as well to specifically assess patron crossing of the Jones Falls Boulevard at Shot Tower/Market Place, either at grade or by a pedestrian tunnel connected to the station.

Bus Passenger Interface. This measure addressed the relative convenience for those transit users who would transfer at Johns Hopkins Hospital Station between feeder bus and rail transit services.

Bus Operations. This subheading addressed the bus routing and operating cost impacts of the various off-street bus transfer facility locations associated with the Johns Hopkins Hospital Station.

Rail Operations. The measure addressed the impacts of a condition or alignment on rail service operations and costs including handling of emergency situations. The location of the crossover at Hopkins is the focus here. It also includes station-related operations.

Traffic Impacts During Construction

This measure addressed the degree to which the construction of an alignment section or station affected traffic flow. The elimination of cut-and-cover construction for line sections reduced the impact of construction on traffic; however, construction access shafts and the delivery and removal of materials associated with tunneling could affect traffic flow. The stations and associated facilities would all be constructed using the cut-and-cover construction technique.

Displacement and Relocation

This measure is based on the number and character of the residences and businesses that would be displaced and would have to be relocated.

Environmental Impacts

This category focused on two areas that are of specific concern along the corridor: impacts on parklands and historic properties and noise and vibration impacts from both construction and operations. Other environmental concerns were considered in the development of the alternatives; however, none of the impacts was found to be significantly different among the various conditions or alignments. The two areas of specific concern are

Parkland and Historic Areas. This category related to the short-term disruption or the long-term impacts of the station or alignment on the several open-space or historic structures and areas in the corridor.

Noise and Vibration. This issue addressed construction or operational noise and vibration associated with a station or alignment. It was a particularly critical concern in the vicinity of Church Home Hospital and Johns Hopkins Hospital as well as near historic structures and where the alignment passed beneath structures.

Community or Agency Concerns

This measure reflected the positions and attitudes of the various public agencies, community groups, and residents expressed at meetings and public hearings during the AA/DEIS phase of the project development, or in subsequent meetings. The opinions were concerned primarily with the location of station entrances and location of the cut-and-cover construction.

Private Sector Participation

This heading addressed the degree to which a station condition provided the opportunity for joint development at the station or for possible private sector contributions to the capital or operational funding for the station.

Component Assessment

In the second step of the evaluation, the station conditions and alignments were assessed for each of these measures. The set of alignments and each set of station conditions were assessed separately, because the purpose was to determine the preferred option in each group. The participants in this assessment represented the relevant engineering, architectural, construction, and operations disciplines to ensure that knowledgeable input was provided.

The evaluation was conducted using indicators expressing the ranking of each option relative to the others within its group. The scale used was as follows:

\+ + Significantly better

\+ Better

o Neutral (or average)

\- Worse

— Significantly worse

Neutral (or average) meant the component had no significant impact on that measure relative to the other components, or it fell into the middle of the ranking. NA was used in cases where the measure was not applicable to the alignment options.

Figure 4 shows the summary of the evaluation in a matrix form. The individual rankings represent the consensus of the task force established to conduct the alternatives evaluation.

The overall assessment for each set of components was as follows:

- *Shot Tower/Market Place Conditions.* Condition 2, the station straddling the Jones Falls Boulevard, clearly ranked as the preferred location for the Shot Tower/Market Place because it provided direct access to both sides of the Jones Falls Boulevard (perceived as a community barrier and safety factor), served the interest of both the business community and the Jonestown neighborhood and had no significantly worse adverse impacts compared to the other conditions.
- *Johns Hopkins Hospital Station Conditions.* Condition 8, with the mezzanine that provided a direct tie into the northern bus facility, the best access relative to the existing hospital and commercial activities, and access to the future hospital development west of Broadway, ranked as the preferred arrangement for the Johns Hopkins Hospital Station although Condition 6 also had certain attractive features as well.

	Station Condition									Alignment I			
	1 Baltimore M of JFB	2 Baltimore Straddle	3 Baltimore E of JFB	4 Diagonal E of JFB	5 Fayette E of JFB	6 Broadway N Oriented	7 Broadway (N) #15 Crossover	8 Broadway N Oriented	9 Broadway S Oriented	I Fayette	II Baltimore	III Baltimore Broadway	IV Baltimore Fayette
Construction and Cost													
Constructibility	-	0	0	+	0	0	0	0	+	-	0	+	0
Cost	0	0	-	0	-	+	+	-	-	0	0	0	0
Service Aspects													
Patronage	+	++	-	--	--	+	0	0	0	NA	NA	NA	NA
Passenger Convenience & Safety	+	++	-	--	--	+	--	++	0	NA	NA	NA	NA
Bus Passenger Interface	0	0	0	0	0	+	-	+	0	NA	NA	NA	NA
Bus Operations	0	0	0	0	0	0	0	0	--	NA	NA	NA	NA
Rail Operations	0	0	0	0	0	0	-	0	0	0	0	0	0
Traffic Impacts During Construction	0	-	0	+	--	--	-	-	0	-	0	0	0
Displacement/Relocation													
Residences	0	0	0	-	0	-	-	-	0	0	0	0	0
Businesses	0	0	0	-	0	-	-	-	-	0	0	0	0
Environmental Aspects													
Parkland/Historic Areas	0	0	0	-	0	0	0	0	0	0	0	0	0
Noise/Vibration	-	0	0	0	-	-	-	0	+	-	-	+	-
Anticipated Community Concerns													
Agencies	+	++	0	0	-	+	+	+	0	0	0	0	0
Neighborhoods	-	-	-	-	++	0	0	0	0	+	-	-	-
Business Community	++	+	-	-	-	+	0	+	0	0	+	+	+
Private Sector Participation	++	++	0	+	0	0	0	+	+	NA	NA	NA	NA

++ Significantly Better + Better 0 Neutral - Worse -- Significantly Worse NA Not Applicable

FIGURE 4 Components assessment matrix.

Additionally, Condition 6 had a comparative cost advantage of approximately $3.5 million in terms of 1986 dollars. Thus, the preference for Condition 8 was tempered by the additional costs associated with it and Condition 6 was also considered as a preferred station condition at Johns Hopkins Hospital Station.

- *Alignments.* Alignment III was the preferred route of the extension, primarily because it was farthest from the Church Home Hospital operating suites on Fayette Street (vibration during construction issue), had distinct advantages in constructibility over other alignments, offered the greatest flexibility in selecting station locations, and had the least potential for noise and vibration to be transmitted to sensitive receptors without costly mitigating treatments.

Step 3: Alternatives Assessment

In this step of the assessment process, the preferred station conditions and alignments became the basis for the evaluation of the alternatives. A table listing the remaining alternatives, shown in Figure 5, provided columns for indicating by symbol the preferred station conditions and alignments as a result of the previous component assessment. The six alternatives that included the preferred Baltimore Street/Broadway alignment (Alignment III) received a symbol under the Alignment Assessment column. The four alternatives that contained the preferred Shot Tower/Market Place Station straddling the Jones Falls Boulevard (Condition 2) each received a symbol under the Shot Tower/Market Place Station Assessment columns.

In the instance of the Johns Hopkins Hospital Station Assessment column, symbols were shown for both the extended mezzanine option (Condition 8) and the north-oriented conventional station option (Condition 6). Although Condition 8 achieved a slightly higher rating than the preferred Johns Hopkins Hospital Station condition, the difference in rating between it and Condition 6 was minimal and, as indicated previously, it carries a higher comparative cost of about $3.5 million in 1986 dollars, which was of sufficient magnitude to warrant further consideration. Because these two station conditions were so close in overall assessment and were the only ones to receive a positive composite assessment in this group, the resulting preference for Condition 8 was not sufficiently strong enough to warrant automatic elimination of Condition 6 for this step in the process.

For the purposes of evaluating alternatives to arrive at a preferred alternative, any station condition that did not have at least a positive composite rating was considered as not acceptable for further consideration. On this premise, Station Conditions 3, 4, 5, 7, and 9 were therefore eliminated from further consideration.

In the case of the alignment options, the number of applicable evaluation factors was fewer and the relative differences between them were less pronounced. Consequently, although Alignment III was clearly the preferred option, because the cost differences between the alignments are minimal and the station conditions appear to be more dominant in selecting an alternative, no alignment was categorized as not acceptable at this time.

As can be seen from Figure 5, only Alternative III.A had a symbol in all three columns, which meant that it contained

Alignment	Alternative Description	Station Condition: Market Place	Station Condition: Johns Hopkins	Alignment and Construction Method	Market Place Station	Johns Hopkins Station	Comments
Fayette (Alignment I)	I.	5	6			■	
	I.A.	5	7				
Baltimore (Alignment II)	II.	1	6			■	
	II.A.	2	6		■	■	Lower cost range
	II.B.	3	6			■	
	II.C.	1	7				
	II.D.	2	7		■		
	II.E.	3	7				
Baltimore/Broadway (Alignment III)	III.	1	8	■		■	Higher cost range
	III.A.	2	8	■	■	■	Higher cost range
	III.B.	3	8	■		■	Highest cost Cond. 3 unacceptable
	III.C.	1	9	■			
	III.D.	2	9	■	■		Lower cost range Cond 9 unacceptable
	III.E.	3	9	■			
Baltimore/Fayette (Alignment IV)	IV.	1	6			■	
	IV.A.	4	6			■	
	IV.B.	1	7				
	IV.C.	4	7				

■ Preferred from Figure V-1

FIGURE 5 Alternatives assessment matrix.

all of the preferred elements: Baltimore/Broadway alignment (Alignment III) with a Shot Tower/Market Place Station straddling the Jones Falls Boulevard (Condition 2) and the extended mezzanine station (Condition 8) at Johns Hopkins Hospital. Consequently, it could be considered a preferred alternative.

However, by reference to Figure 3, it can also be seen that Alternative III.A has a comparative cost ($102,576) that is in the higher range of costs. It was decided, therefore, to review those alternatives that had only two symbols, a somewhat lesser preferability, but whose comparative costs were significantly lower. There were four alternatives that display two symbols, two of which had equal or higher comparative costs, one that had lower comparative costs but contained an unacceptable station condition and one that had lower comparative costs ($99,026), and both preferred station conditions with an acceptable, if not preferred, alignment. This last alternative was Alternative II.A.

The evaluation process thus far had reduced the number of contending alternatives from 24 to 18 to 2. Comparison between Alternatives III.A and II.A needed to be addressed with further investigations, as are discussed in the following section.

COMPARISON OF ALTERNATIVES II.A AND III.A

The assessment areas found to be significant in the comparison of Alternatives II.A and III.A are shown in Figure 6.

The first column of Figure 6 lists the assessment areas. The next column identifies those assessment areas that are believed to be important in making the comparisons between Alternatives II.A and III.A. The next two columns display the summary evaluation for Johns Hopkins Hospital Station Conditions 6 and 8. The last two columns are for the combination of station condition and route alignment. These last two columns also contain an indication as to which is the preferred alternative for that assessment area, wherever such a preference can be established.

It can be seen from Figure 6 that Alternative III.A was preferred from the standpoint of noise and vibration, because any negative impacts in this area should be easier to mitigate. This preference resulted from the fact that the track crossover for Alternative III.A is located further away from particularly sensitive areas such as the Wilmer Eye Clinic (where microsurgery is performed), and the alignment is further from the Church Home Hospital operating suite. On the other hand, the current comparative cost estimates indicated a preference for Alternative II.A because it was less expensive than Alternative III.A.

With respect to patronage, the analysis showed that Alternative II.A was better, but the additional potential patronage was so small as to discount this advantage to the point that the two should be considered virtually equal. The site conditions that help shape station configuration were such that Alternative III.A was preferred with respect to architectural and functional layout. Alternative III.A also offered somewhat better geological conditions for tunneling and consequently had less design and cost risks or uncertainties.

In terms of operating characteristics, Alternative II.A offers a shorter overall travel path of about 500 ft. This difference becomes a factor in train operating mileage when the line is extended north of Johns Hopkins Hospital Station because it represents additional car mileage for each one-way trip through this segment of the system. Alternative II.A also has an 80-ft shorter length of line from Charles Center Station to the end of construction. On the other hand, Alternative II.A has somewhat more curvature. The total angular direction change for Alternative II.A is about 143 degrees, versus 123 degrees for Alternative III.A.

Although both alignments require some underground easements for tunneling beneath private property, Alternative II.A was somewhat preferable because it avoided easements under Church Home Hospital. Discussions and negotiations for easements at Church Home Hospital would undoubtedly be time consuming, and would include consideration of indemnification against damages occurring during construction and operation. However, Alternative III.A offered an advantage in ease of mitigation noise and vibration due to the physical distances separating the alignment from sensitive areas such as the Church Home Hospital operating room and the Wilmer Eye Clinic. Finally, Alternative III.A was judged to be preferable to II.A with respect to adverse traffic impacts.

Overall, the cost advantage associated with Alternative II.A resulted in its selection as the preferred alternative. Subsequently, additional noise and vibration analyses were conducted and mitigation measures were developed to minimize noise and vibration impacts. This alternative has proceeded through final design, and construction was initiated in July of 1989. The extension, as shown in Figure 7, is scheduled for revenue operation in 1994.

SUMMARY

A procedure enables the evaluation of a large number of alternatives against a broad range of criteria and the identification of a preferred alternative, or at least a reduced set of alternatives and criteria that can be handled with a more traditional evaluation process. The essence of the procedure is to isolate significant differences among the alternatives by a sequence of disaggregation and aggregation of components and sets of alternatives, and identify where the clear preferences exist and where they do not. The procedure also promotes a clearer understanding of the evaluation criteria and the relative importance of each. In each step, only those criteria that differentiate the alternatives are applied.

This procedure reduces what could be a clearly unmanageable situation—in this example, 24 alternatives and dozens of evaluation criteria—to a series of steps that are not only manageable by the participants but also the results and procedure are presentable to others. This procedure has application to a broad range of transportation planning and design conditions. This general procedure has been applied in several other transportation planning projects. Recently, it was used to define a set of transit alignment options to carry into an AA/DEIS for an extension of the Baltimore Central Light Rail Transit Project. Here, the objective was not to select a preferred alternative, but only to reduce a large number of

Assessment Area	Very Important?	Station Condition		Stations and Alignments			
				6 + Alignment II		8 + Alignment III	
		6 Assessment	8 Assessment	Assessment	Prefer?	Comments	Prefer?
Noise and vibration	Yes	Not as good	Better	More Problem at JHH and Church Home Hospital	-	Better - Further from crossover	Yes
Comparative Cost	Yes	Less money	More money	(Basis for comparison)	Yes	$3-4 million more for line and station	-
Bus/Rail Transfer and Patronage	- Yes	Better	Not as good	Better, but difference is small	?	-	-
Architectural Function	-	Not as good	-	-	-	-	-
Operations	Length - Yes Curvature - Yes	-	-	Less, better path More Curvature	Yes -	Longer path Less Curvature	- Yes
Constructability	-	-	-	Not as good	-	Better geology - Less risk for tunneling	Yes
Easement Requirements	Somewhat	-	-	Better, but still a problem	Somewhat	Not as good because of Church Home	-
Ability to Mitigate	-	-	-	Not as good	-	Better	-
Traffic Construction Impact	-	Not as good	Better	-	-	-	-

FIGURE 6 Comparison of Alternatives II.A and III.A.

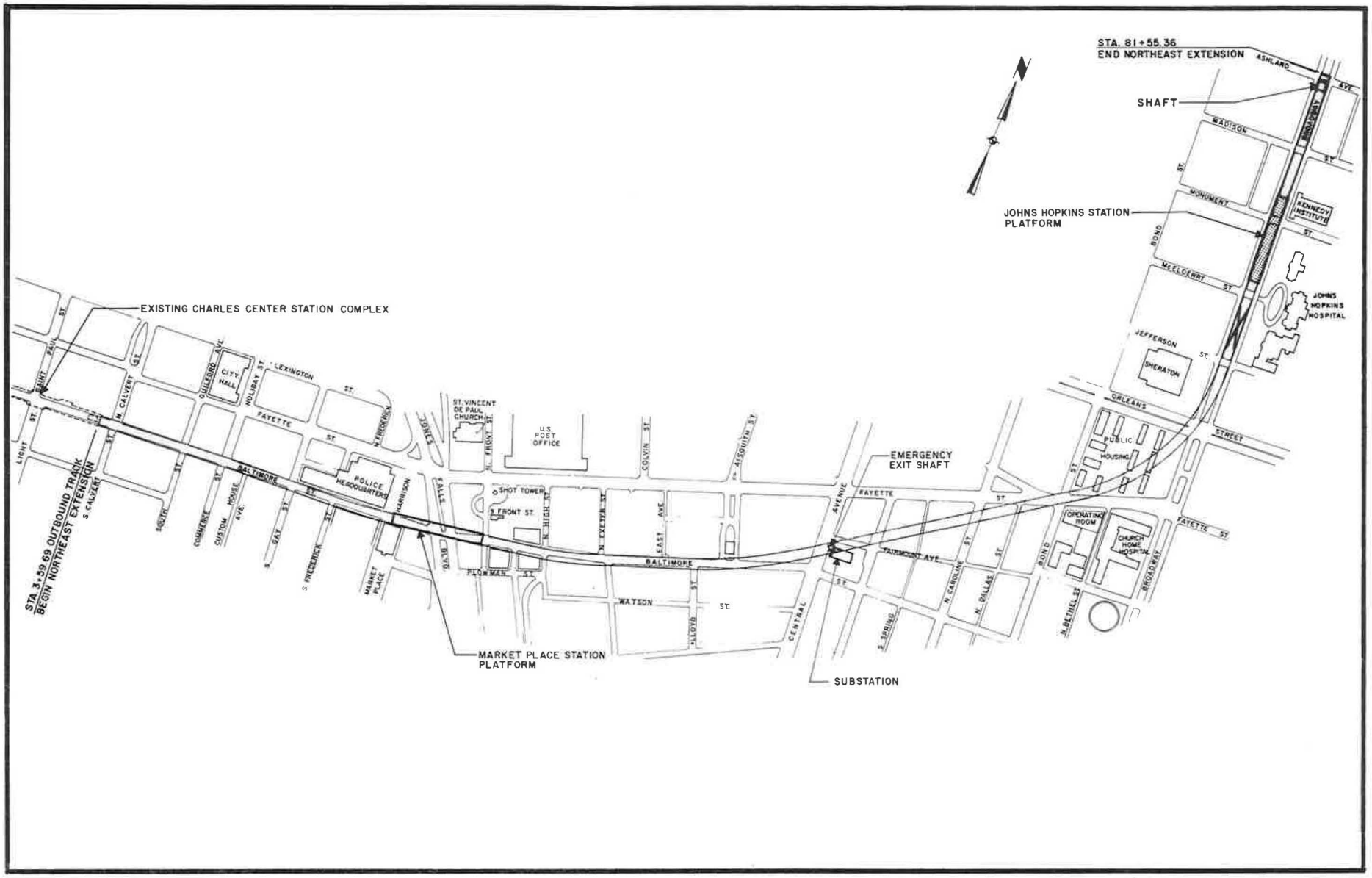

FIGURE 7 Baltimore Section C Metro extension.

options, many with mix-and-match components, down to a set of two to three alternatives that are to be subjected to more detailed analysis and evaluation during the alternatives analyses process.

ACKNOWLEDGMENTS

The authors would like to acknowledge the assistance of David Miller of Parsons, Brinckerhoff, Quade, and Douglas, Inc. and of Walter Kudlick of Kudlick Consultants, who helped develop the procedure, and to acknowledge the many participants in the procedure from the Maryland Mass Transit Administration and the Baltimore Metro Section C general engineering consultants DKP (Daniel, Mann, Johnson, and Mendenhall; Kaiser Engineers; and Parsons, Brinckerhoff, Quade, and Douglas, Inc.).

Publication of this paper sponsored by Committee on Intermodal Transfer Facilities.