Formation of Criteria for the San Diego LRT Project

W.P. QUINTIN, JR., Bechtel Civil & Minerals, Inc.

Light rail is a flexible form of transit; for this reason, special attention must be given to the development of project design criteria. As bases of a project's specifications, these criteria must invite bids suitable to its financing and schedule. They must reflect the particular program, that is, they must be derived from the same plan and must project the same combination of ridership, service efficiency, and schedule speed.

The design criteria for the major subsystems on the San Diego Light Rail Transit Project were derived in this way. Specific criteria for vehicles, trackwork, signals, traction power, and fare collection were developed, and methods for design integration were explored.

One of the characteristic features of light rail transit is its flexibility—its ability to operate within a wide range of conditions. Thus, a number of solutions may be used to meet goals, and the project design criteria for civil work and equipment may permit considerable scope.

Such criteria must be suitable to form the bases for plans and specifications that can be competitively bid in the public domain. In addition, the resulting civil work and equipment design must fit immediately into a practical operation.

The development of practical LRT project criteria therefore takes place in two steps. First, criteria must be developed that clearly reflect the transportation requirements on which the project was conceived. Second, the subsystem designs are combined so that criteria can be consolidated as much as possible.

DERIVATION OF PROJECT CRITERIA

Project criteria are derived from the initial transportation plan on which the decision was made to select light rail transit for the project. The transportation plan is based on the lowest level of service that will sustain the necessary patronage and revenue. Thus, the result of the first part of criteria formation is that the light rail system must produce the commercial speed and service frequency required to meet passenger demand, and do so cost-effectively.

This first part of criteria formation also requires development of an operating plan, which eventually becomes the basis for determining the details of the project criteria. The operating plan is a basic strategy—rather than a schedule—for evaluating the physical requirements for station sites, the track plan, vehicle configuration and fleet size, power loads, signaling capabilities, and fare collection schemes.

The second part of criteria formation is the consolidation of various subsystem designs to serve common functions. Light rail transit projects have a low economic tolerance for "on project" experimentation. Accordingly, the consolidated designs for most projects are similar. Due to this similarity, projects can use generally practiced construction and operations methods and standard "off-the-shelf" equipment. Thus, the criteria are formed to identify those design combinations that are particular to the project.

DEVELOPMENT OF CRITERIA

The San Diego Light Rail Transit Project, conceived in 1978 and put in revenue service 3 years later, was derived from project criteria formed by the two major steps outlined above.

Operating Plan

The operating plan for San Diego had its inception when the San Diego Metropolitan Transit Development Board (MTDB) selected the San Diego and Arizona Eastern (SD&AE) Railway corridor between downtown San Diego and the international border (United States/Mexico) for light rail transit operations. This selection was made, in part, as a result of a study and findings by Wyer Dick and Co., presented to the MTDB in May 1978[1]. The report and transportation plan described specific methods for operating the low-volume SD&AE freight traffic and light rail transit traffic jointly on the same facility. The transportation plan was based on a modest growth of SD&AE traffic, and projections showed that freight trains could traverse the transit corridor without service disruption whenever the transit headway was at least 30 minutes.

This joint operation was based on the use of a single track line with passing sidings for transit meets every 7.5 minutes. For through freight trains, i.e., those running directly between San Diego and points east of the transit terminal at the international border, space would be given in the transit pattern from a vacant run in the 15-minute service. For the local freight service, the train would use switching leads to serve a collection of spurs in the same general area. The local would then run between switching leads in a vacant transit slot to serve the intermediate spur.

The initial transit patronage would come from passengers diverted from a parallel local bus line, and the service was expected to attract additional patronage. The base transit service was projected to be 1500 passengers per hour in the peak direction; thus a 15-minute headway was stipulated for both peak and base periods.

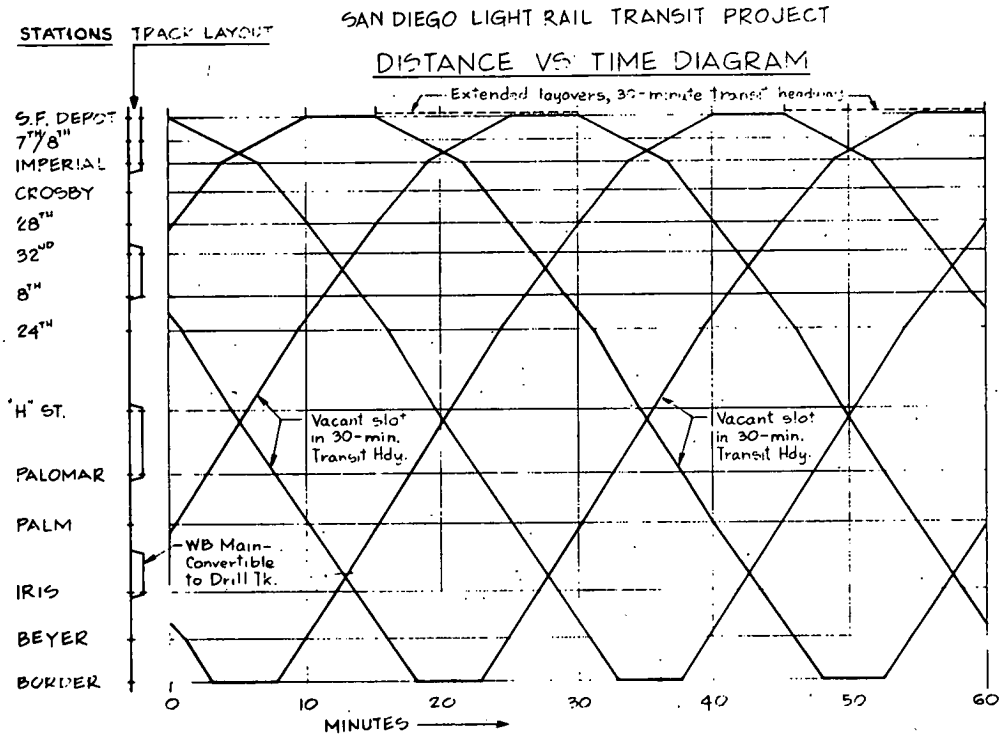
Because fast travel times mean a small fleet size, reduced labor requirements, and lower operating costs, the theme of the operating plan was to minimize circuit time (i.e., the time for one round trip, including two layover times). Accordingly, the operating plan was developed by using a significantly higher commercial speed—almost twice the 13-mph average for buses—to compute practical run times. The circuit time was calculated to be 75 minutes, and this became the principal criterion for vehicle performance.

From the project viewpoint, base functions of the transit car were for the first iteration of the operating plan. The approximate size of the vehicle was determined by the 1500 maximum hourly load point patronage. With the stipulated 15-minute service, the maximum design train load would be 375 passengers. It appeared that the market would offer a 64-seat car. Thus, with a fairly large percentage of standing riders during peak patronage periods and a vehicle with approximately 64 seats and room for 2 standees per seated passenger, peak service trains would have 2 cars each.

Route data were also needed for the first iteration of the operating plan and were also derived from the transportation plan. The principal route of the transit system was the SD&AE track. However, the main transit terminal was in Centre City and would require construction of tracks in streets. This part of the plan was the subject of considerable civic and political interest. At the time of the first iteration of the operating plan, the Centre City terminal was at C Street and Twelfth Avenue, and the border terminal was near the former SD&AE depot. In addition, 10 intermediate stations were indicated on the SD&AE corridor.

As the operating plan was developed, the project criteria began to form. Stipulated data were confirmed or

Figure 1. Operating plan.



altered, and the project functions were clarified.

On Figure 1, the operating plan is conveyed in graphical form x(t), i.e., distance versus time. The graph shows a 1-hour module of peak period operations. The plots are loci of points traced by each train movement indicated.

The operating plan is interpreted largely through this graph. Each trace indicates the position and timing of each train movement with regard to other train movements. Through study of this graph, particular operating problems can be seen and possible alternatives examined. Practical consequences of train delays or changes of schedule or the effect of a remedial strategy to recover from an off-normal condition can readily be seen. In addition, the requirements for fleet distribution, utilization, and staffing can be derived from a study of this graph.

The graph is the basis for criteria in three major functional areas of the plan.

First, the operating plan graph indicates the basic single-line track plan. It locates the meets and the effects of variation in meets. Where crossovers or freight train yard entries or pullouts are made, the graph indicates the tolerance and workability of conflicting moves on whatever schedule is under study. Terminal operations, particularly those in Centre City, are clearly described so that the effects of alternative routing for utility repairs, on-line storage, or short turns for fire or accident can be readily understood.

Second, the whole graph is the basis for traction power design criteria. Individual vehicle propulsion is the initial data, but the operating plan exhibits the sum effect. The traction power load varies for each train generally as a function of place. Because any function of place on this plan is also a function of time, these data produce the traction power design criteria and requirements for installed capacity and the distribution of substations.

Third, the operating plan graph produces signaling criteria. These criteria indicate where block limits may be located without interfering with train spacing for trains operating either on allowable headways or on reduced headways during pattern recovery. The graph does not provide highway grade crossing protection criteria, but it does provide the base data for traffic light coordination when trains operate on city streets.

Functional Consolidations

In the development of project criteria, the full criteria were developed for each of the major subsystems and then consolidated. Some important functional combinations that led to consolidated subsystem criteria on the San Diego Project are discussed below.

Signals and Power

The operation on a single track provided opportunities for consolidation of signaling and traction power criteria. The economy of the design and operation provided no intermediate meet locations, and all meet tolerance was provided on double-track sections used as long sidings. This required a tight pattern in 15-minute headway operation, i.e., trains could not get out of pattern without risking some difficult recovery problems. After the system opened, the pattern was loosened to a 20-minute headway. There are a number of slow orders due to present parallel construction of track, and the Centre City traffic coordination is not yet complete. At some future time, a tight pattern with 15-minute headways may be reinstituted.

Because of the project's basic commitment to economic light rail transit operation, it was decided early that signals would be designed for normal operating conditions only. The transit operator would have to develop operating procedures and rules for handling off-normal problems. Thus, the block signaling became absolute, and the criteria relied on there being no normal following moves within individual signal blocks.

With no following, the signal design was simplified, and the amount of traction power that could be drawn from the catenary and nearby substations was limited. A freight train doing switching "owns" the block so that it can drill with a little more flexibility than it might otherwise. In addition, transit cars may turn back anywhere in a single-track section merely by changing ends.

Circuit Time

As the operating plan emphasized the importance of circuit time, every aspect of the project that could protect and conserve the operating circuit time was included in the criteria.

In the operating plan, it quickly developed that running meets would provide the best margin to protect circuit time, particularly if the double-track sections had one or more stations to draw out the run time. So that the double-track sections would not be overextended, the criteria limited doubling to avoid major civil work, e.g., bridges, cuts, and fills. Thus, the meet locations and the track plan were juggled to optimize the operating plan and maximize the margin for circuit time disruption.

Also consolidated in the criteria were the requirements for fare collection procedures and vehicle door use to protect the circuit time against the effects of loading large numbers of passengers.

Vehicles and Tracks

Consolidation of track plan and the vehicle criteria involved a trade-off between double-ended versus single-ended vehicles and the track plan. It appeared that there would be physical difficulties if loops or wyes were allowed at the terminals. It also developed that there were advantages favoring single-sided stations in single-track sections. These points favored the double-ended, double-sided vehicle with sufficient passenger capacity.

Due to the requirements for joint freight/transit operation, it was inevitable that the track plan would include some criteria governed by the railroad but with an effect on transit. The net consequence of joint operation for design was that the average speeds of a freight and transit train had to be roughly the same. As transit equipment is capable of relatively high performance and a freight train is not, it was proposed that the freight train be brought up to speed and kept there by minimizing any need for speed reduction. This means that freight trains must be able to move on and off double-track sections at or near their average speed. To meet this objective, long-point No. 20 turnouts at the ends of double track were adopted as project criteria.

Because freight service has been perpetuated, the project has generated some on-line industrial development. One of these is located in the vicinity of Iris Avenue station. A switching lead for the projected switching services was provided for in the original criteria. After it was noted that joint operations would occur when the transit service headway was 30 minutes or more, criteria were developed to vacate the transit slots meeting at Iris Avenue. The signal criteria therefore provided for the conversion of the westward main at Iris to a switching lead when not used as a double track.

Under the general orders of the California Public Utilities Commission,[2] even with allowance for partial relief for cause, the minimum contact wire height above top-of-rail is 22 feet. This is beyond the reach of the standard pantograph of some light rail transit vehicles. For others, it is close to the maximum effective range. The criteria were developed to avoid long trolley poles and shoes, roof platforms, and heavy locomotive pantographs. However, the narrowness of the pantograph operating range and the effects of sag in fixed-registry catenary virtually mandated the constant-tension catenary scheme that was subsequently designed and installed.

Because the line must continue to carry railroad interchange equipment, the design criteria provided for railroad-type trackwork. There is no flange bearing special work throughout the system. This necessitates a wide-tread, deep-flange railroad wheel with which the transit car is equipped.

The side clearance profile of freight train equipment is wider than that for transit equipment. Consequently, the transit system platforms cannot project above top-of-rail. Therefore, the criteria require transit cars to accommodate passenger loading at street level throughout the system.

Future Expansion

From the outset, because of limited funding, the design criteria prohibited hard design for possible future expansion. However, the developed criteria did allow design that could be expanded.

Expansion of system capacity is possible through double tracking. This solution was not available in the original project criteria due to funding, but because it was feared that patronage might soon increase to double the project feasibility level, this quick remedy was accepted to increase the passenger-carrying capacity.

The possibility of an increase in freight service was considered, but was not deemed as likely as the doubling of transit patronage. If freight train movements were increased to a pair of daytime through trains, one in each direction, transit service headways would have to be reduced to 30 minutes to accommodate the move.

Under such expansion, train lengths would double to four cars and the installed traction power capacity would be increased proportionally. The basis of this expansion is both expressed and implicit in the developed project criteria, which provide for multiple unit vehicle capability and prefabricated portable substations. Thus, substations can be relocated and added to serve the increased train size and prevent an unacceptable drop in line voltage.

CONCLUSION

Design criteria can be derived from the original project plan for corridor, patronage, and service speed. The resulting base specifications give form to the otherwise flexible possibilities that are characteristic of light rail transit.

The design criteria on the San Diego Light Rail Transit Project were derived in this way. The specifications based on these criteria invited suitable bids and materially contributed to the project's coming in under budget and on schedule.

REFERENCES

1. Wyer Dick and Co. A Report and Operation Plan of San Diego and Arizona Eastern Railway. Prepared for MTDB, May 1978.

2. General Order 95, Rules for Overhead Electric Line Construction. California Public Utilities Commission.