Evaluation of Visual Impacts of Trolleybus Overhead Catenary System Intersections

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This paper presents an approach to evaluating the visual impact of trolleybus overhead catenary system (OCS) intersections based on the quantity of special work hardware required to construct the intersection. Examples of various intersection types are presented using both diagrams and photographs, and a scoring system is developed. The scoring system is used to rank common intersection types and produce a scale of visual impact that can be used to evaluate unique intersection configurations. The effect of street width on the visual impact of intersections is discussed, as is the related effect of advance turn lanes. Approaches to reducing visual impact by changing intersection layout are illustrated and their effect on bus operations is discussed.

A method for evaluating the visual impact of intersections in trolleybus systems is presented in this paper. This approach can be used with the illustrations in this document to evaluate the most commonly used intersection types. It can also be applied to evaluate the visual impact of trolleybus overhead catenary system (OCS) intersections that are designed to fit unique street and bus movement patterns.

TROLLEYBUS OPERATIONS AND SYSTEM DESIGN

Although the general structure of transit routes is defined by the demand for service, there are many other factors that can influence route location at the specific street or intersection level. Among these are the feasibility of street use, turning movements, and environmental concerns such as noise. In the case of trolleybus routes, an additional factor (often replacing other environmental concerns) is the visual impact of the OCS. There are numerous opportunities to reduce visual impact by subtle changes in route design that have little or no impact on service to the public. Many of these will affect such elements as turnback loops, garage routes, and emergency detour capability that are largely invisible to the transit user.

The goal in trolleybus system design should be to avoid the use of system elements that are visually obtrusive. In general, special work (switches, crossovers, and curve segments) is more obtrusive than straight trolley wire. Use of these components should be avoided or minimized when feasible to do so without significantly affecting operations.

The first step in designing OCS for trolleybuses is to determine the amount of wire and special work that is actually needed. This requires the preparation of a system wire map showing revenue routes with scheduled turnbacks as well as garage access routes. Garage access routes must take into account both minimizing running time and minimizing the amount of nonrevenue wire.

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Any new system is likely to use vehicles with some auxiliary power capability. The simplest auxiliary power system using batteries is sufficient to eliminate the need for most of the wire found on existing systems that is not regularly used. This includes both wire and special work used only in emergencies and wire used infrequently on a scheduled basis. APU use will require additional stops for removing and replacing poles. Thus, frequent use in revenue service will substantially degrade travel time.

Emergency wire is most often provided in downtown areas, where a street closure will affect multiple routes. Most transit systems that use trolleybuses have a sufficient number of spare diesel buses to substitute for trolleybuses on one route, but can only schedule multiple route substitutions on weekends or late evenings.

Figure 1 shows an OCS design in an area of downtown Seattle. The wire that is used for scheduled service, including garage movements, is differentiated from the wire needed only in emergencies. It can be observed that one intersection and two blocks of wire could be eliminated with APU availability and that the two most complex intersections would each require less than half the special work than is used in the current design.

Another means of reducing the amount of wire and special work is to review the regular route operation to determine if there are any route variations that operate infrequently and could be handled by rescheduling or with the APU. For example, there may be two short turn locations that are used at different times of day that could be combined into a single location. Another example is a situation in which a few late evening trips operate over both branches of a route that is otherwise scheduled with alternate trips on each branch. Here, the APU could be used for the turn connecting the branches.

INTERSECTION EVALUATION

Although the appearance of an intersection is influenced by several factors, including street width and the placement of special work within the intersection, the most important factor is the amount of special work in the design. In particular, complex intersections, or intersections requiring a large number of special work components, can be visually overpowering.

In order to evaluate the visual impact of trolleybus OCS intersections, it is first necessary to develop a rating scale. The rating scale proposed is based on a count of the number of special work components used in the intersection. For this purpose, a weighted count is used, with switches and crossovers having a weight of 1 and curve segments having a weight of ½.

This weighting was selected because a curve segment is basically a flat plane object visually, and thus has significantly less impact from the motorist's or pedestrian's perspective than does a switch or crossover. These elements contain section insulators, jumpers,

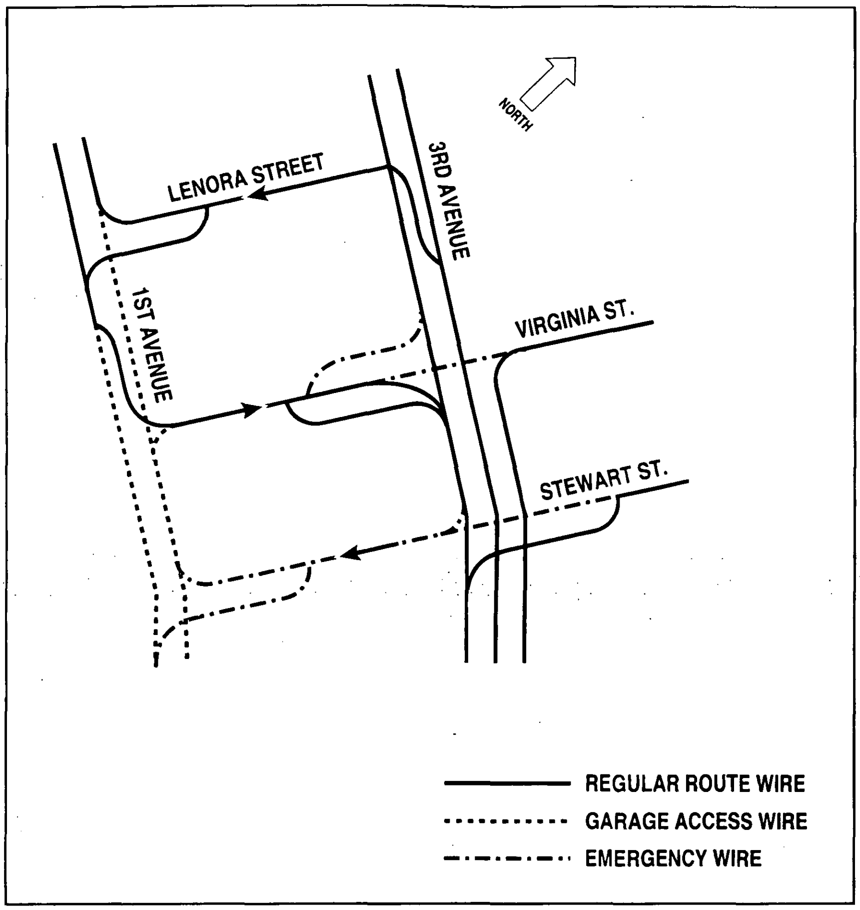

FIGURE 1 Regular route, garage access and emergency wire, north end of Seattle CBD.

and switch-operating hardware that protrude a noticeable distance above the plane of the wire and thus make the element more visible at the usual shallow view angle. In plane view, a switch, crossover, or curve segment all appear to have about the same visual mass.

As previously noted, this analysis is most useful for the more complex type of intersection. A system with dense route grid, such as San Francisco or Vancouver, will have a large number of complex intersections. A system that is primarily radial will have not only fewer intersections, but most of these will be relatively simple types. For example, Seattle, which is a combination of a radial and a grid system, has 96 intersections with switches or crossovers. Sixty-three of these intersections are simple, while 33 are complex.

A simple intersection is one that has a visual impact rating of 5 or less. Examples include a right turn into a turnback loop, with a visual impact rating of 2; a left turn in the same situation, with a visual impact rating of 4; a crossing of two routes without turns, with a visual impact rating of 4; and a turn combined with a transition between one-way and two-way operation with a visual impact rating of 5. This last configuration is shown on the right and left sides of Figure 2 below.

Figure 2 presents plans for several types of complex intersections. These are:

1. Diverging route;
2. Half wye;
3. Crossing with one pair of turns;
4. Full wye;
5. Crossing with two pairs of turns (1/2 grand union); and
6. Crossing with all possible turns (grand union).

Photographs of the first five types are shown in Figures 3 to 7. No complete grand union exists in the United States or Canada, so that it is included as a theoretical worst case.

Table 1 gives the number of special work elements used in each type of intersection and gives a visual impact rating for each type.

The complex intersection types shown in Figure 2 are shown because, except for Type 6, these tend to be commonly used configurations. For example, in Seattle, 25 of the 43 complex intersections are represented by Types 1 to 5, with 18 being Type 1 or Type 2.

Intersections similar to the first two types, with visual impact ratings in the range of 6 to 8, appear to be suitable for use at any location. Intersections similar to the second two types, with visual impact ratings in the range of 9 to 15, may be used in most locations but should be avoided in the most visually sensitive areas if feasible. Intersections with visual impact ratings of greater than 15 should be avoided unless there is no feasible alternative.

This approach will be useful not only in evaluating the visual impact of the common intersection types described above but also for assessing the visual impact of unique intersection designs. Figures 8 and 9 show two unique intersection types. In Figure 8, a crossing with one pair of turns is modified to include a four-wire local and express-wire layout on one of the streets. The effect is to

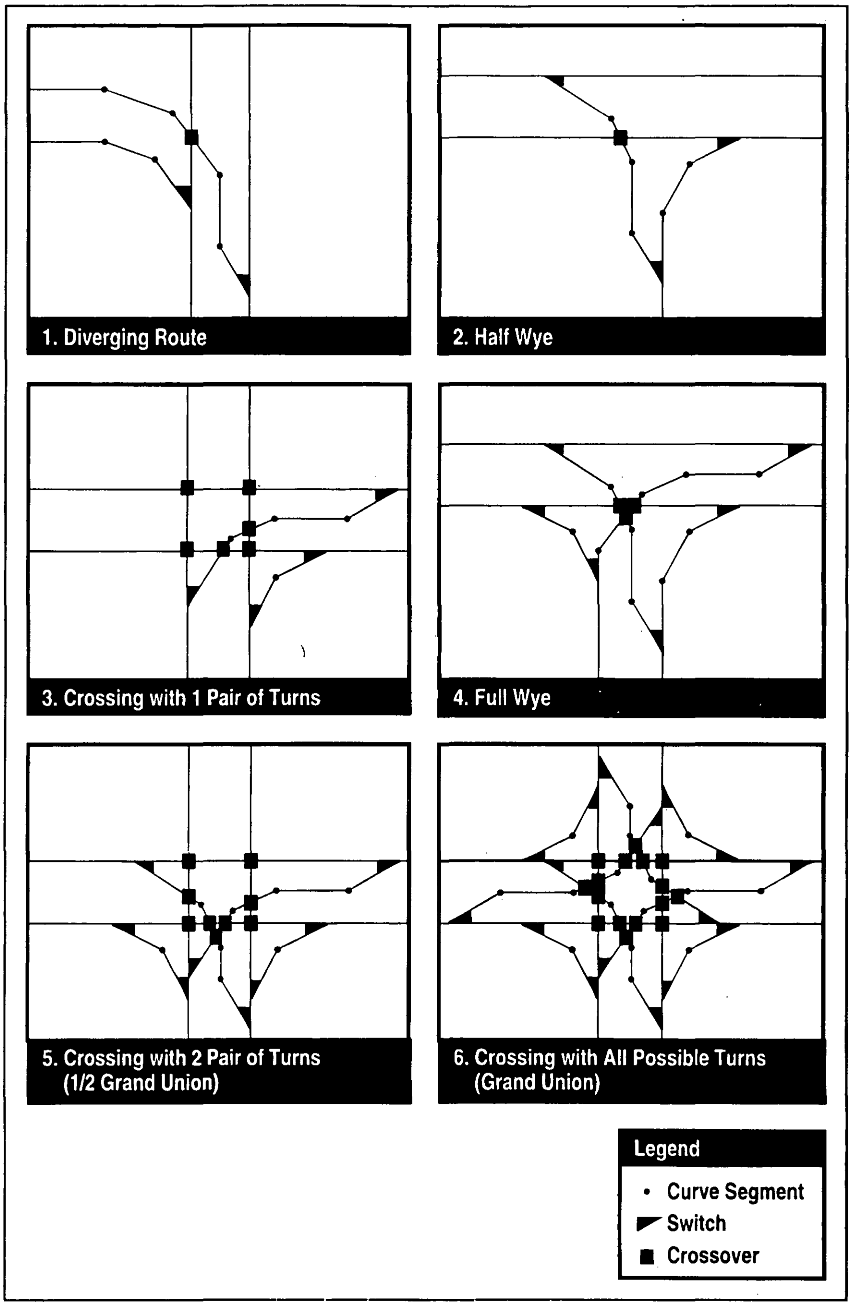

FIGURE 2 Intersection types.

TABLE 1 Visual Impact Rating of Intersection Types

Type	Switches	Crossovers	Curve Segments	Visual Impact Rating
1.	2	1	6	6
2.	3	1	5	6.5
3.	4	6	4	12
4.	6	3	10	14
5.	8	9	8	21
6.	16	16	16	40

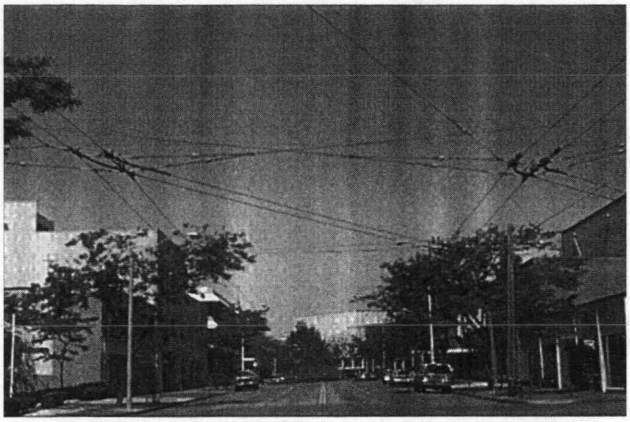

FIGURE 3 Diverging route, Third Ave. and Cedar St., Seattle (Type 1—visual impact rating: 6). Note directional control contractors ahead of facing switch.

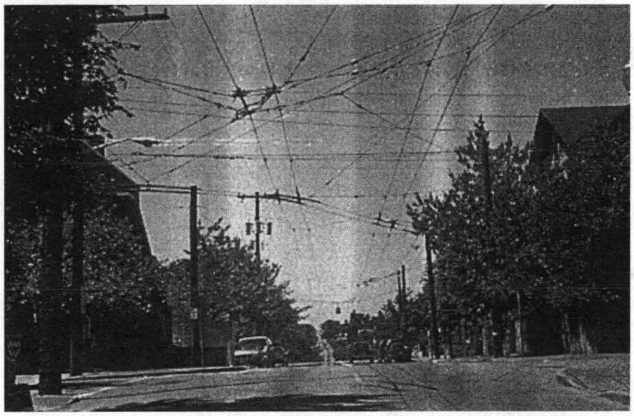

FIGURE 4 Half wye, 33rd Ave. and E. Union St., Seattle (Type 2—visual impact rating: 6.5).

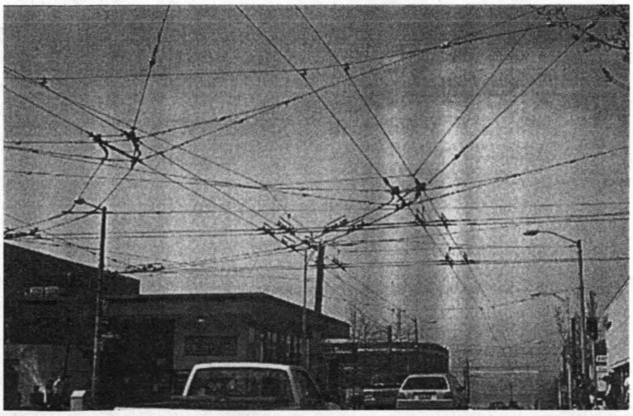

FIGURE 5 Crossing with one pair of turns, Broadway and John St., Seattle (Type 3—visual impact rating: 12).

FIGURE 6 Full wye, Queen Anne Ave. and Boston St., Seattle (Type 4—visual impact rating: 14). Note inductive antenna and the control cable and box on pole at right.

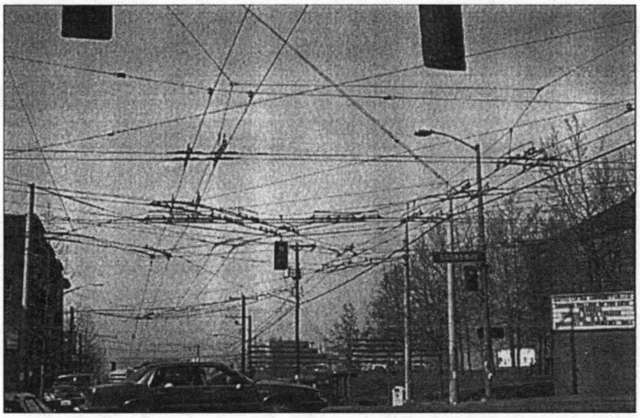

FIGURE 7 Crossing with two pairs of turns (1/2 grand union), Broadway and Pine St., Seattle (Type 5—visual impact rating: 21).

increase the number of crossovers from 6 to 12 and raise the visual impact rating from 12 to 18.

Figure 9 shows a two-way diagonal street crossing a one-way street grid. This intersection requires eight switches, seven crossovers, and only three curve segments for a visual impact rating of 16.5. Even with this level of complexity, only five of eight possible turn movements are included. This figure also shows that there are situations in which turns of 60 degrees or less can be installed without the use of curve segments.

ADDITIONAL CONSIDERATIONS IN INTERSECTION DESIGN

One approach to reducing special work concentration is to utilize one-way operation, both for route location in dense areas and for garage access. The use of separate streets for garage entry and exit will result in two intersections, each with around half the visual impact of a single intersection used for both entrance and exit routes.

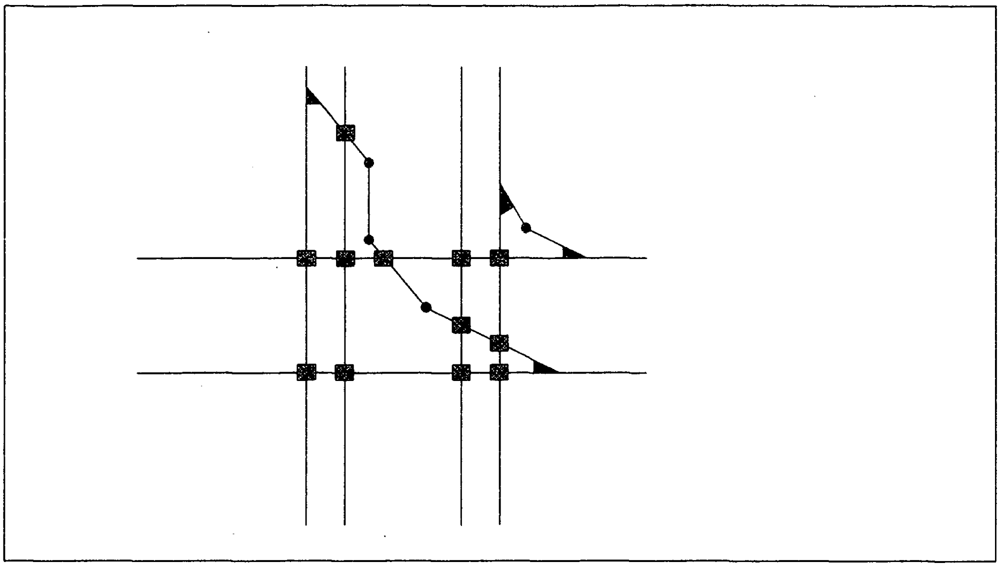

FIGURE 8 Crossing with one pair of turns with four-wire street.

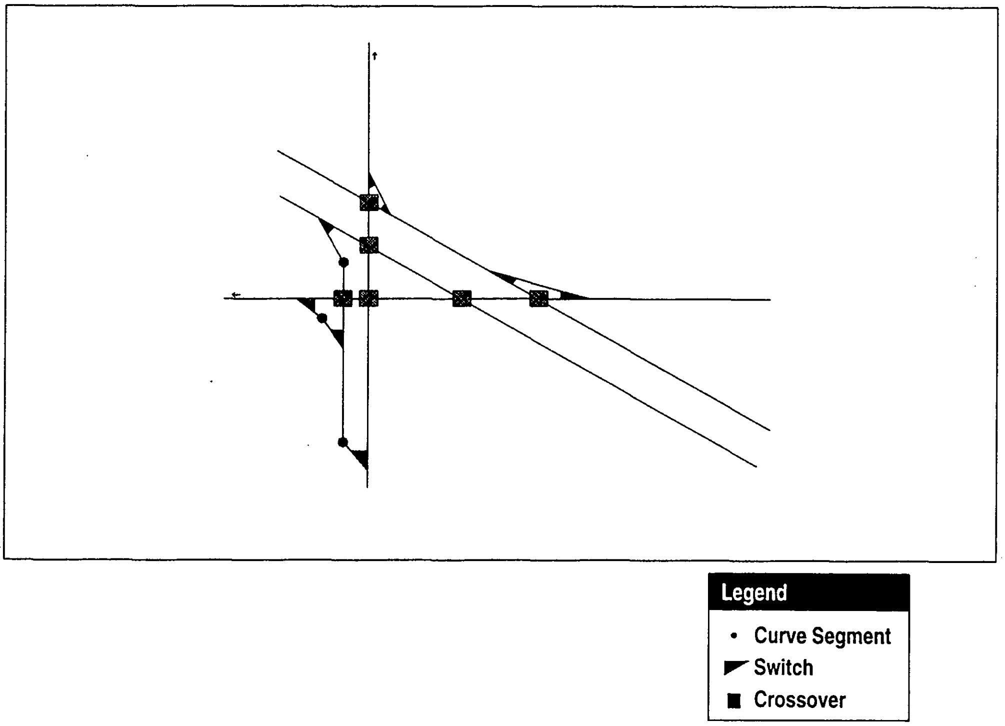

FIGURE 9 Two-way diagonal street crossing; one-way street grid.

One-way operation on parallel streets is often feasible in downtown areas, even though the streets are used for two-way traffic. Even when a single "Main Street" is used by many transit routes, the intersection streets are often appropriate for one-way operation.

For example, an intersection of two streets with one-way wire with both turns, as shown in Figure 10, has a visual impact rating of 7. Four such intersections replace the grand union of Figure 2, which has an impact rating of 40. Even when bus movement is concentrated on two intersecting streets, the use of a parallel street and the dispersal of turn movements will reduce the impact of special work substantially. The layout shown in Figure 11 uses four intersections with impact ratings between 5 and 7 to provide the capability for all possible movements.

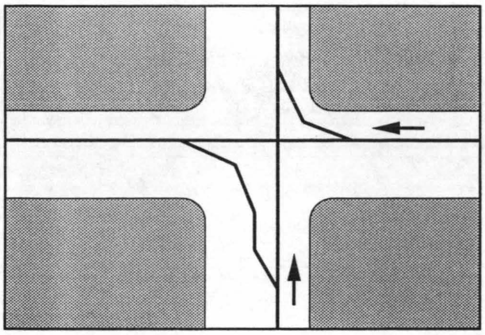

FIGURE 10 Intersection of two streets with one-way wire and both turns.

On streets with two-way wire, right turns produce less visual impact than left turns in that crossovers are not needed and the special work is kept out of the center of the intersection. Thus, where feasible, a right turn should be used rather than a left turn to provide the same movement capability.

Street width will also affect the visual impact of intersections. Straight wire is usually designed with the negative (curb-side) wire between 9 and 14 ft from the curb, depending on parking regulations and system preference, thus establishing the location of intersection approaches. Thus, the spacing of special work elements will vary depending on street width. Figure 12 shows a diverging route on a narrow street. The same configuration on a much wider street is shown in Figure 4.

Advance turn lanes can have either a positive or negative impact on the appearance of an intersection. When used on a narrow street, advance turn lanes can produce a cluttered look, as shown in Figure 13. However, advance lanes do serve to move switches out of the intersection, thus reducing the impact of concentrated special work.

Generally, an advance turn lane should be used for all left turns when there are two or more lanes of moving traffic in the direction of the turn approach. An exception may occur when the turn is not regularly used. In some locations, an advance left turn can be designed with a gradual shift in the wire from the normal position to the left turn position. This will both reduce visual impact and often improve operations. Advance right turn lanes are appropriate only when there are two or more lanes of moving traffic and when high levels of pedestrian movement commonly delay right turn movements.

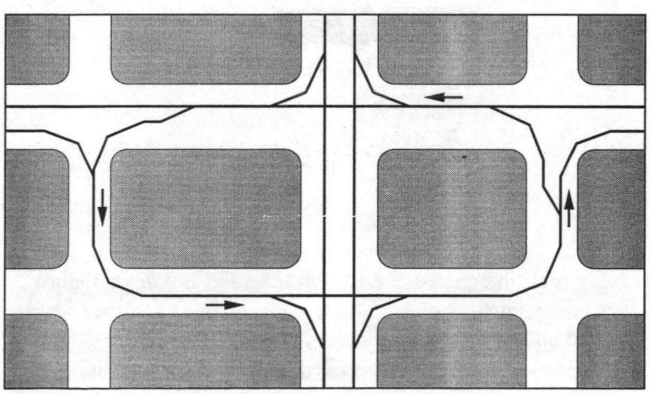

FIGURE 11 Use of one-way wire to provide all possible turns without complex intersections.

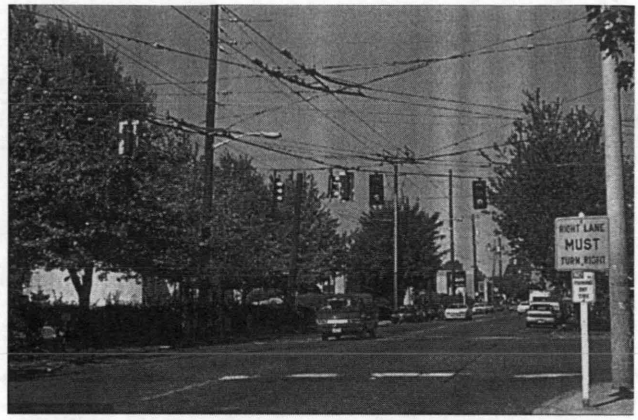

FIGURE 12 Diverging route on narrow street; 15th Ave. E and E. Thomas St., Seattle. Compare this figure with Figure 3 to observe effect of street width on appearance.

FIGURE 13 Advance turn lane on narrow street; Divisadero and Jackson Sts., San Francisco. Note that advance turn lane can be used only by moving into opposite direction through lane.

Trailing turn lanes, as well as long advance lanes, can be used to allow turning vehicles to bypass bus stops. This design feature is usually found in downtown areas where different route groups have separate stops on the same street. Trailing turn lanes offer no other operational advantage and are not recommended except for this purpose.

Finally, although garage OCS design is not part of this paper, it should be noted that garage OCS sometimes overflows into an adjacent street. The use of street access to individual garage tracks should be avoided if at all possible, as the concentration of special work and poles will be much greater than in any other design situation.

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