3

Planning Light Rail

3.1 Setting Goals and Objectives

All planning must start with a clear set of objectives. Since planning, including traffic and town planning, became an academic discipline, a considerable body of literature has been written on the importance of setting clear objectives in plan making (Figure 3.1). Confusing and sometimes mutually contradictory objectives were heavily criticized by the UK National Audit Office 2004 light rail report. This was a wide-ranging and severe criticism of the new light rail and tramway systems it reviewed, which had been open since 1990 in Britain.

Figure 3.1 Plan and objectives (Drawing: L. Lesley)
In particular, the promoters of the systems had claimed objectives to justify the public funding that were rarely met in part, let alone in full.

The more objectives a project is trying to achieve, the less likely it is any of them will be satisfied. Often in a transport, or light rail, project there are implicit or hidden objectives, like “civic keeping up with the Joneses” or the ruling party rewarding the parts of the city where its electoral strength lies. In the US, this is called “pork barrel politics.” Is seeking votes in marginal areas of the city close to gerrymandering?

What are suitable objectives for light rail and how can they be framed? There is a large body of planning literature on this topic, and this is an attempt at a concise summary. Objectives can be normative or derived. In the first case, the objective is to achieve an accepted norm, like reducing air pollution to the specified healthy or safe level or enabling people to reach their place of work within a defined time. Normative objectives usually can be measured and therefore can be readily confirmed as to the effectiveness of achievement by a project. For a light rail system, these would be carrying x% more passengers or achieving a y% market share.

Derived objectives begin with an analysis of the existing situation to identify particular problems found in that city. Often, subjectivity confuses such analyses. This certainly can be the case when comparing the severity of different attributes, even if it cannot be measured exactly. For example, is reducing traffic congestion more important than encouraging development? Derived objectives usually emerge from market research, public consultation exercises, or consultants’ studies. Objectives like reducing traffic congestion or social exclusion fall into this category, since even defining what these “problems” are is difficult. Measuring them is also difficult. Identifying any statistically significant change, against what is often a noisy data background, can be impossible. This can degenerate into the kind of medieval debate about the number of angels that can fit on the head of a pin. Nevertheless, much political debate is undertaken using this kind of language or rhetoric, and without doubt, where public bodies are involved in promoting or funding light rail projects, derived objectives will be part of the justification for a new project.

Another approach is the identification of widely accepted problems and then seeking their solution. This approach can be more difficult, as there is rarely a consensus as to what constitutes a problem. On the other hand, if problems can be agreed upon, then solving them is easier than planning to achieve normative objectives. Solving problems might seem easier, but it is not so easy to achieve, since there is usually more than one solution that can be applied. The job of the (transport) planner is, then, to find, examine, evaluate, and select the alternative most likely to achieve a solution to the accepted problem. Doing this without creating further problems—the so-called law of unintended consequences—is not always so easy. Solving prob-
lems and providing the best value for the money invested, from whatever source, is the most difficult challenge of all.

It ought to be obvious that transporting people is the most important objective for a light rail system. In most American and European cities, the car is the main means of personal transportation. The objective of a light rail system should therefore be to change the modal split, at least of peak period travel (Figure 3.2). Achieving a change in modal split is easy to measure and, given the size of the motor car market, provides the light rail system promoter with a large pool of trips from which to attract ridership and revenue.

A light rail system that does not carry passengers must surely be a non sequitur. As the UK National Audit Office revealed, this has nearly happened in the UK. Promoters claimed that the light rail lines built would break even on operating costs, but they have required considerable subsidy to be kept open, because patronage did not reach 50% of the promoters’ forecast.

Simply measuring the number of riders using a new light rail line is not adequate and can be misleading. Riders may have diverted from parallel bus or rail services, not increasing total transit ridership. Establishing that riders have genuinely been attracted from private car use is also not without problems. Before and after studies of household travel behavior can identify statistically significant modal split changes. These can be confirmed from transit rider surveys. Similarly, cordon surveys of commuters entering the central business district can identify modal shifts, especially where linked to long-term passenger and vehicle counts on the corridor benefitting from the new light rail line.
Where new light rail projects are promoted and in part funded by property developers, the rise in land values or property prices will be of considerable interest to the developers, who will wish to see their investment in light rail rewarded. Indeed, a pioneering study of the Yonge Street Subway Line, which opened in 1954 in Toronto, showed that within 5 years much of this transit investment had been recouped from the rise in land values and sales around station locations (Dewees 1976). Similar conclusions were identified more recently in Seoul (Bae et al. 2003).

The first stage of the London Docklands light railway, which opened in 1988, was paid for within 3 months of the start of construction, through the rise in the value of brownfield sites and land sales. In many places, however, such overheated land value conditions do not apply. Declining heavy industrial cities may effectively have land that has a negative value, due to contamination and the cost of restitution, especially if the population is also in decline.

Unfortunately light rail will make little difference in such cases, as witnessed in the Midland Metro in Birmingham, UK, which crosses large areas of industrial dereliction around Wednesbury (“The Black Country”). The lack of development therefore means it does not carry enough passengers to cover costs. These are cross-subsidized from National Expresses local bus services. Nor has this light rail line produced either brownfield redevelopment or economic regeneration.

This is an example of a political light rail project. A previous attempt to build a light rail line was rejected because of the large areas of demolition proposed. Ironically, the name of a citizens’ action group, SMART (Smethwick Against Rapid Transit), is “TRAMS” spelled backwards. The “soft” option of an abandoned rail right-of-way was chosen instead. This ignored the fact that it hardly served any residential or work areas but does serve a football stadium. The traffic from that however (one afternoon every two weeks) is not enough to compensate for the lack of traffic the rest of the time.

Other objectives like urban regeneration, improving the environment, or reducing social exclusion are unlikely to result in extra revenue for the light rail system promoter. These and other worthy social and similar objectives, while conferring community benefits, assuming they can be detected, are unlikely to assist directly in the finances of the light rail project.

Social objectives might be considered as fortunate side effects but really should not be counted as key. If they are, is this a sign of a weak project? Light rail, like transport in general, is a service industry and not a driver of the economy. Cities with weak economies need to address the economy and not imagine that light rail is a miracle regenerator. This is true even if a property developer is promoting the project as part of a package to open up access to an underused site. In this case, the property developer will pay for all or part of the capital cost and offset that against the rise in the value of
his land bank that otherwise might not be developable. Economic regeneration came from the redevelopment of the land, not the construction of a light rail system. Light rail promoters must not confuse cause and effect.

3.1.1 Public Consultation

In North America and Europe, there is a legal requirement for public consultation for all publicly promoted projects, including light rail. Consultation is not just informing the public of plans. The reason for this is partly the democratic process, to ensure that public money is wisely spent. It is also partly a “good neighbor” exercise, to determine what the effects on residents and businesses in the area will be and how any negative effects can be ameliorated. There are formal consultation processes in a number of countries. In the US, these have been set out for more than 30 years (US Department of Transportation 1976) (Figure 3.3).

The key to effective public consultation is stimulating feedback, both positive (support) and negative (objections). Normally, people with objections are more than willing to make them known and, if there are enough, to band together into an opposition group. The promoter must then address

![Diagram](Sample Chapter)
fully all objections. There are two main ways to achieve that. In the first, the light rail plans can be modified to remove, or at least substantially resolve, the issue. If this is not practical, then the objectors can be compensated. While there are many examples where public consultation was successful, the cases where consultation has failed can also be salutary.

One such example of failure was the West London Tramway. It was promoted by Transport for London to replace tram line 7, originally abandoned in 1938 along the Uxbridge Road, replaced by electric trolleybuses, which in 1962 were themselves replaced by diesel engine Routemaster buses. The West London Tramway was to be built through the boroughs of Hammersmith, Ealing, and Hillingdon. Very quickly, residents and business organized an opposition campaign, based on a number of objections. The objections were mostly very reasonable and revolved around the residents’ access to facilities in their area and the impacts on local businesses.

The campaign was led by a national journalist, Virginia Ironside, also a local resident. All the objections could have been resolved if measures and traffic management techniques in widespread use in the rest of Europe had been offered. Instead Transport for London took a “take it or leave it” approach. The result was that in the 2004 municipal elections, the ruling Labour Party lost control in Ealing and Hillingdon to the Conservatives, who had campaigned on an “anti-tram ticket.” The Conservatives immediately withdrew support. The Labour-controlled Transport for London had no choice but to abandon the project, after spending £50 million on preparations and consultation.

For a new generation of privately funded projects, as well as the legal consultation process, the promoter will begin with local market research, to find out residents’ views of their district and city. A private light rail promoter also will seek to influence public opinion. Champions will meet civic leaders to present the case for and the benefit of light rail to the city.

From whichever angle a new light rail system promoter comes, good public consultation is more than a legal requirement; it makes very good sense to ensure the system is acceptable to the citizens through whose “front yard” it will pass. As importantly, public acceptance is needed to gain political support and the maximum ridership. For the public sector, ridership should be the most important objective. For a private promoter, maximizing the revenue generated will be critical to achieving the business plan projections and satisfying investors.

3.2 Demand

How many passengers will a new light rail system carry, and what is the maximum revenue that can be generated? The answers to these two questions
are not the same, because the fare elasticity for urban (public) transport is rarely \(-1.0\); more normally, it is about \(-0.3\). In one project with a 19-km light rail line, the maximum patronage was found when no fare was charged and a maximum revenue at about 65% of the maximum patronage. In urban areas, there are already people making trips. The purpose of those trips is known: to go to work or for education (the two most important economic activities) or to go shopping, visit friends, seek medical treatment, and so on.

Similarly, the method of transport used to make these trips is also known—or easily determined. Finally, as nearly 80% of trips start or finish at home, the origin and destination of trips, together with the start and finish time, can be determined. This data is vital in the planning of a new light rail line, as it allows modal shift calculations to be made and therefore the likely ridership that can be attracted and under what conditions.

Looking at data (e.g., 40 years of the UK National Travel Survey) that records the travel pattern of people making trips for all the above reasons, one fact stands out: the number of trips made per capita has remained remarkably stable at about 1100 annually. What has changed is the average trip length, reflecting the real decline in the cost of travel during this period and the modal switch to the use of private cars. Why has the number of trips made remained stable? The principal reason is that trips for work (or education) dominate most people’s lives, and normally these accounts for two trips on most days.

In fact, the amount of travel consumed reflects the classic economic demand/cost curve (Figure 3.4). In the future, the number of trips made is

![Figure 3.4 The economic demand/cost curve (Drawing: L. Lesley)]
likely to remain broadly static, since there are only so many activities that people can undertake in a week. What will change are origins and destinations and therefore trip length and the mode of transport.

The light rail promoter relies on the fact that a person’s mode of transport can be changed in the short term. In the light rail corridor, this can be immediate by people in cars switching to light rail. In the medium term, with the swirl of people changing jobs and housing, more will choose to locate for convenience to the light rail line. Also in the medium term, the light rail system, by enabling or perhaps providing more intensive economic developments, will also change origins and destinations, by allowing more people to live or work near the line.

As people move to live closer to the light rail line, this will enhance adjacent house prices. A 30% rise was reported from the opening of the Tramlink system in Croydon (UK). The enhancement of property values near light rail lines, compared to those further away, has been noticed in many cities. This urban restructuring can reinforce the role of the light rail system and capture a larger share of urban trip making, from typically 2% to more than 5% of all trips per line, or up to 40% of the movements in that corridor.

3.2.1 Origin and Destination Traffic

Ridership on a new light rail line will be attracted or diverted from the existing travel pattern. Conventionally, an urban area is divided into, as far as possible, homogeneous traffic zones (Figure 3.5). Travel between zones either will be determined from household or similar surveys (Bonsall and O’Flaherty 1997) or will be calculated from the population for origin traffic, and number of jobs and retail or leisure space for the destination.

Plotting the desire lines between all combinations of origin and destination zones produces a bewildering pattern for a metropolitan area of about one million people. For this reason, the data produced is recorded in an origin-destination matrix (Bonsall 1997). While data for trips by all modes and for all purposes can be recorded in a single matrix, the light rail planner will be particularly interested in car trips for all purposes, since these will represent the largest and most attractable traffic potential.

The light rail promoter will also need origin-destination data for trips between the zones that lie along the proposed light rail line or, the other way around, will seek the lines through zones which already have the heaviest traffic flows. Trips from one zone to another which passes through other zones en route will also be of interest. In designing the light rail alignment, the planner will seek to maximize the number of these trips that can be attracted by convenient stations and journey speed.

In most urban areas, there are few end-to-end trips on any particular light rail line. Most trips are between intermediate points. Therefore, knowing the
origin-destination matrix data is an important foundation, both in designing the lines of a new light rail system and determining the ridership that can be attracted.

### 3.2.2 Generalized Cost

In economic theory, the demand for products (or services) increases as the cost declines and vice versa (Figure 3.4). This classical analysis is based on the cost as the actual cash transaction for obtaining the product or service. Over the last 30 years, transport economists have used considerable market research to demonstrate that the cash cost of transport is not a good measure of people’s travel consumption behavior, which was already known due to fare elasticity.

**Figure 3.5 Urban traffic zones: desire lines from just one zone to all others (Drawing: L. Lesley)**
A result of this market research is that other factors were found that influence choice of travel mode. These factors take into account the comparison between alternative modes of transport that can be used for a journey. Most importantly, the quality of the journey was considered more important than the financial cost of the travel. All of these factors were moderated by a traveler’s value of time. Bringing these different factors together was made possible by the construction of a “generalized cost.”

Generalized cost has a good correlation with passenger transport demand (Figure 3.6). Generalized cost brings together financial and service attributes and then weighs them against people’s willingness to pay. This is usually a function of income and the economic importance of the journey. In broad terms, richer people are willing to spend more on transport to save travel time, by buying speed, while poorer people spend more time traveling on lower cost modes to save money. There are many volumes devoted to the consideration of generalized cost, but here we will consider its basic relationship. A fuller explanation, references, and worked examples can be found in Appendix 1.

The starting point is the fundamental relationship in the demand/cost curve:

\[ N = \frac{k}{GC} \]  

(3.1)

where \( N \) = the demand (measured in passenger kilometers), \( GC \) = generalized cost, and \( k \) = a constant, usually city specific and also a calibration constant.

This relationship is good for specific journey purposes, so a disaggregated analysis of each journey purpose should be undertaken to arrive at the most exact relationships needed for light rail traffic predictions. Fortunately, most
of the journeys made in the peak period are work related, and a very acceptable approximation can be calculated by analyzing two journey categories: work travel and all other travel as nonwork.

The advantage of generalized cost is that it allows comparisons to be made between different modes of transport, as well as the impact of changes in one or more aspects of a particular mode.

The generalized cost function can be written as:

\[ GC = c_1 \cdot T_1 + c_2 \cdot T_2 + c_3 \cdot T_3 + c_4 \cdot F + c_5 \cdot D \]  \hspace{1cm} (3.2)

where \( c_1, c_2, c_3, c_4, \) and \( c_5 \) are constants and \( T_1 = \) walking time, \( T_2 = \) waiting time, \( T_3 = \) riding time, \( F = \) out-of-pocket costs (fare), and \( D = \) a measure of perceived comfort and safety. From a large number of studies, \( c_1 \) and \( c_2 \) are nearly equal to 2. Often, \( c_1 \) is about 1.8 and \( c_2 \) about 2.2, indicating the relative willingness of people to walk but a lower inclination to wait. \( c_3 \) usually is almost 1.0, meaning that people perceive riding time at about clock time. \( c_4 \) is about the inverse of wage rates for work journeys and between 0.5 and 0.1 for nonwork journeys.

People’s disinclination to wait is nicely illustrated by a study undertaken by London Transport at Earl’s Court Underground station in London. Here there are both elevators and escalators between the deep-level platforms and the street. On average, elevator time is significantly shorter than escalator time. Most passengers use the escalators, because normally they can be used without a wait.

Equation 3.2 produces a value of generalized cost in terms of equivalent minutes, as opposed to one based on equivalent money. Using equivalent minutes as the measure of generalized cost has a number of important advantages, since:

- Time is a measure that can be compared across different countries
- Time is inflation (money) proof, allowing direct comparison over a number of years
- Time intuitively gives a better measure in making a lower generalized cost correlate with increased travel
- Time allows different income groups to be considered on the same basis

Generalized cost can be used to determine the absolute measure of travel demand or, given existing data on demand, can be used to analyze the effect of changing the transport system as follows:

\[ \frac{N_1}{N_2} = \frac{kGC_2}{kGC_1} \]  \hspace{1cm} (3.3)
Therefore:

\[ N_2 = N_1 \cdot \frac{G_{C1}}{G_{C2}} \]  

(3.4)

where \( N_1 \) is the existing travel demand, \( G_{C1} \) is the existing generalized cost, \( G_{C2} \) is the generalized cost of the new situation, and \( N_2 \) is the resultant travel demand.

This has the further advantage that the calibration constants cancel, assuming they remain the same or nearly the same during the period of change. Normally these calculations are undertaken for changes during the next year, rather than over 10 years. Thus, only the relative change in generalized cost needs to be determined, making predictions of changes in demand that much easier to calculate, including sensitivity analyses.

### 3.2.3 Elasticities

Another way to determine travel demand, although normally only on aggregated data, is the use of elasticities (Figure 3.7). This is the economic measure of people’s willingness to pay and can be considered as the slope of the demand/cost curve at the particular point being considered. In the urban public transport industry, a fare elasticity of about \(-0.3\) has been the norm for about 40 years. This means that if fares are raised by 10%, demand drops

![Figure 3.7 Fare elasticity](Drawing: L. Lesley)
by 3%. Total revenue increases by about 7%. This confirms the basic point of generalized cost. The cash/fare element in the decision to travel is not the only or even most important factor. The equation to calculate fare elasticity can be determined from the slope of the fare/demand curve (Figure 3.7):

$$e = \frac{dN}{dc}$$  \hspace{1cm} (3.5)

where $dN$ = the change in demand caused by the change in fare, $dc$ = the change in fare, and $e$ = elasticity of demand.

What it also means is that it has been assumed that fare elasticity behaves in the same way for fare reductions. Thus, a 10% fare decrease will lead to only a 3% patronage increase, leading to a reduction in revenue of about 8%. The literature on fare decreases is much smaller than that on fare increases, since there have been fewer of them, during a period when there has been constant inflation, and although fares have sometimes not risen with inflation, due to subsidies, this is not perceived to be a fare reduction. In fact, in most places fares have risen faster than inflation, to compensate for the systematic decline in (bus) traffic.

There are cases of fare increases leading to patronage increases, due to the change in the fare system. An example of this was in 1979 when the Rhein-Ruhr VV in West Germany changed from a route-based distance fare scale to a simple zonal fare system. This coincided with an average fare increase of 10%. A patronage decline of 3% had been budgeted. In fact, patronage rose by 4%, allowing for new investments that for the next 20 years created positive feedback on ridership and revenue.

Given the level of money inflation over the last 40 years, it has not been possible to distinguish with any confidence the long-run elasticity of fares. Few passengers have short-term options and cannot make immediate changes in travel behavior. In some countries, there are programs to encourage car sharing. Where this is possible, a transit user can team up with a car driver at work, share the fuel costs, and become transit independent.

The intuition is therefore that the long-run elasticity is higher than the short run. Passengers without immediate choices can over a period make radical changes to their lifestyle. Such changes include buying a car, moving one’s home to be more convenient for work, and changing jobs as the three most obvious. These will have profound impacts on mode choice and the ridership of transit services.

Studies on the impact of new car purchases in the UK showed that the first car purchased in a household reduced public transport use by about 360 trips annually, whereas the second car purchased reduced transit use by about 280 trips a year (Hills 1981; Goodwin 1993; Paulley et al. 2004; Cheek 2008).
More recent work (Paulley et al. 2004) shows that urban bus fare elasticity in the UK is now about –0.4, reflecting the fact that many bus trips are optional, as very few people are dependent on buses for the work journey. The implication of this higher elasticity is that a 10% fare increase will boost revenue by about only 5%. Bus operators cannot therefore assume that rising costs can be met by raising fares, which has been the method used by most operators in the past 40 years. This has exploited the short-term fare elasticity while ignoring the long-term elasticity. Now that the short-run elasticity is higher, raising fares will merely collapse the business faster. This is the main reason why UK bus operators have recently concentrated upon cost reduction measures, providing useful experience for potential light rail promoters.

3.2.4 Prediction Accuracy

In planning a new light rail system, the most problematic of the predictions is the patronage forecast. Indeed, the UK National Audit Office 2004 light rail report singled out for criticism the poor accuracy of project ridership forecasts. This was in terms of either not achieving the predicted patronage at all, and therefore lower revenue than budgeted, or at best forecast ridership takes significantly longer to be achieved. Both of these therefore lead to an unbudgeted period of losses, which often are rolled up into the capital costs to be covered by the original grant or public funding.

Light rail promoters normally have few options for reducing costs when opening a new system, if patronage and revenue do not reach forecasts. The infrastructure is fixed and cannot be used for anything else. Some of the rolling stock can be mothballed and staff laid off. This, however, is likely to worsen the problem. A lower frequency of service will further reduce ridership, until the ultimate situation of no service, no revenue, and an idle capital asset.

One way to handle the inevitable, relative inaccuracy of patronage and revenue forecasts is by the use of sensitivity analysis (Table 3.1). Here, in turn, each variable used in the prediction is altered by the same amount, usually 10%, and the impact on the whole forecast is determined. From this, the variable(s) most critical to the forecast can be identified. This allows further work to refine the data for that variable and therefore improve the accuracy of the whole patronage forecast. Ranges of patronage forecasts can also be used in the economic appraisal model to see how sensitive it is to inaccuracies in the patronage forecasts.

None of these techniques by themselves will make patronage, and therefore revenue, forecasting 100% reliable, but at least the likely range of forecasts can be determined and narrowed. A business tool like mini-max analysis can also be used to minimize the worst-case scenario. In a commercial project, investors are likely to consider only the low estimate of ridership demand,
on the basis that if that is adequate to finance the capital, then should demand be higher, investors will enjoy comfortable profits. Publicly funded projects appear to have used only upper forecasts, if the UK National Audit Office conclusions are valid.

### 3.3 Performance

The performance of a new light rail system will be governed by a number of factors, including:

- Quality of the design of the route and stations
- Type of equipment and vehicles used
- Caliber and training of staff
- Operational management and timetable robustness

There are examples of apparently similar light rail systems that have very different performance in terms of passengers carried per vehicle or staff member and number of vehicle kilometers run per year or per staff member. These differences have a major impact on costs.

An example of this is the Supertram system operating in Sheffield, England (Figure 3.8). When set up, it was manned on the basis of six drivers per vehicle with off-board revenue collection from ticket machines. These proved unreliable and expensive to maintain and were frequently vandalized. Patronage built up more slowly than forecast, resulting in an operating loss, which the public authority was unable to fund. The operation was therefore

### Table 3.1 Sensitivity analysis to different operating speeds

<table>
<thead>
<tr>
<th>Speed (km/hour)</th>
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<th>22 faster</th>
<th>25 fastest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>Passengers*</td>
<td>Fares**</td>
<td>Passengers*</td>
</tr>
<tr>
<td>1</td>
<td>0.73</td>
<td>2.9</td>
<td>0.74</td>
</tr>
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<td>0.69</td>
<td>2.7</td>
<td>0.69</td>
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<tr>
<td>4</td>
<td>0.20</td>
<td>0.8</td>
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<tr>
<td>5</td>
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<td>3.5</td>
<td>0.88</td>
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<tr>
<td>7</td>
<td>0.50</td>
<td>2.0</td>
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</table>

* Million passengers per year
** Million dollars per year
privatized to the multinational company Stagecoach, which initially reallocated half the drivers to be fare collectors on the vehicles. Off-vehicle ticket machines were abandoned.

This immediately increased revenue by 7%, which paid for the wages of the fare collectors/conductors. Only three drivers per vehicle was very close to the Stagecoach overall average of 2.9 for its bus fleet. Increasing revenue and reducing costs meant that within 2 years a system that had been losing money was generating an operating profit of about £1 million a year, as noted by the UK National Audit Office, nearly the same sum that Stagecoach paid for the 20-year operating concession.

3.4 Stations and Stops

Passengers access light rail systems at stops or stations. These are the first physical points of contact with the service. They are the “shop window” of the system and will bring into perspective whatever marketing image has been created. Functional and aesthetically pleasing stations need not be expensive and because they have low running and maintenance costs can be a better investment than, say, additional lines or more vehicles.

Stops need to be located to allow convenient access to where people live, work, shop, attend school, etc. In a supply-side analysis, it has been assumed that people will walk 400 m to a transit stop, unless urban development is of varying density. This implies a stop spacing of between 400 and 800 m, with a continuous corridor 800 m wide served, for walk-and-ride passengers.
With park-and-ride, or bike-and-ride in some countries, stations can be further apart without reducing the effective population catchment but with a faster service speed and shorter travel time.

There is an interaction between stop spacing and operating speed. Fewer stops mean a higher operating speed but a smaller passenger catchment area. More stops slow the operating speed but shorten the time spent at each stop to let off or pick up passengers. Like the supermarket line, transit station stop time is a critical factor in maintaining service regularity. One of the main advantages of light rail is that stations have a relatively low capital cost and can be quickly built, even when in street. Having assessed the likely potential traffic generation at stops, a new light rail system might therefore concentrate on the half with the greatest traffic potential and be prepared to add new stations later as revenue is generated, to further increase patronage. This is a decision that can be made only on the basis of excellent local market intelligence.

Adding new stations later has several additional advantages. First, once a system is open, operating performance should improve and therefore higher operating speeds can be achieved, so new stations can be added without needing new rolling stock, by using the extra efficiency gained from experience to maintain the original operating speed. Second, in terms of the local travel market, it allows the operator to be viewed as developing the business, by opening another “outlet” for more customers. Third, it allows the operator to undertake joint ventures with property developers, on land adjacent to the line, and open new stations integrated with the development. Indeed, electric light rail can pass through buildings without any special environmental protection, as is the case in Ludwigshafen, Germany, where a department store was developed with a tram stop inside (Figure 3.9).

As the light rail stations are the shop window of the system, it makes good sense to have high-quality designs and finishes. It is a strategic decision whether to have the same design for all stations or a local design for each station to reflect the personality of the neighborhood in which it is located. Whichever approach is adopted, a corporate identity and clear signage will help passengers find and be guided around the light rail system. Good design should help to reduce any resistance from local residents to having a light rail stop as a neighbor, unless it takes away people’s front yards. This was a factor which led to the demise of plans in the early 1990s for a light rail system in Edinburgh.

A new light rail system will operate at a high frequency of service, so that waiting times are short and therefore the need for station facilities is limited. Personal security is an issue of perception. The evidence shows that more effective than closed-circuit television is a busy station on a well-used system, where social pressure and passenger cohesion both make travel pleasant and give riders a good feeling of safety.
3.5 Land Use Integration

This is a big issue, whether the local government system is based on a tight control of land use or practices a free market philosophy. Transport is a derived demand from land use activity. There is therefore an argument that coordinating decisions on transport and land use development can make good sense (Figure 3.10). If there is a completely free market and the land use developer and light rail system promoter are the same, for profit maximization reasons, the developer will try to integrate land use development with the introduction of a new light rail system. Indeed, in the 19th century, many cities (e.g., Chicago) were opened up by developers acquiring large tracts of land and then building a rail system, hand in hand with property development.

Some city councils have discretionary powers to “tax” new developments to contribute to transit projects. In the US, some cities and states have “value recapture” taxes on property to recoup part of the rise in land values derived from new (light rail) transit systems or other public investments. In the UK, public authorities can “tax” new developments (e.g., in England permission to build can include an agreement [Section 106] where the developer pays for public benefits) to pay part of the cost of new transit systems that are planned for introduction.

Both of these taxing approaches may be resented by developers, who have little or no say in how their money is spent in the light rail project and may see the project as a public sector toy paid for by the private sector. In
extremis, a developer can look into projects in other cities with more favorable tax regimes.

Local authorities often see transport as a “quick fix” for urban problems. This is because a new transport system can be up and running in less than 10 years, whereas comprehensive land redevelopment may take 50 years, time frames in which governments rarely work. Without care, a new transport system can in fact make an existing land use problem worse, by intensifying development at critical and accessible places and leaving other areas starved of investment, suffering from “planning blight,” to become marginal in the urban economy.

Arguing the counter factual case is just as contentious, since without any public intervention (in a new light rail system) parts of the urban economy and fabric will decline and become marginal anyway. In urban development economic theory, this leads to a relative decline in land values until a developer finds the redevelopment of such areas profitable. This was the experience in Liverpool during a 20-year period when the population declined and market prices were lower than new construction.

In all developed countries, local authorities are required to produce development or zoning plans, to guide property developers as to what developments will be acceptable and where they may be undertaken. Such plans may also include proposals for transport system improvements. This can have the effect of guiding developers to particular locations, where transport is likely to be improved, or in some cases to see the transport improvement as part and parcel of the property development.
The impact of these public guidance plans is very critical. On the other hand, a new transport line may have the opposite effect of creating “planning blight,” where property owners stop maintaining and developing, pending acquisition and demolition of their property for the new line. When this is a public sector project, implementation can run into decades, worsening “planning blight” to an overall area decline. With the relative decline in land values, land owners receive little or no compensation if property is required for a transit system. This is another source of public discontent.

3.6 Coordination with Property Development

The best way to integrate land use and transport is to have property developers as investors in the new light rail system. This gives the developers a financial incentive both for the investment in transit and to undertake complementary real estate developments. This will enhance the light rail system patronage and hence the total returns to the investors.

It also means that with better access, the land value will also rise. This avoids what is seen as dead money through the taxing approach discussed in Section 3.5 and mobilizes one or more developers. Making this work requires a genuine partnership between the public and private sectors. Although there are many examples in the US and in continental Europe, sadly to date there are few such partnerships in Britain.

Even if there is no direct relationship with property developers, a new light rail line will have an impact on the property market. Research in Germany (Hass-Klau 2004) showed that property prices in the catchment area of a new light rail system rose between 9 and 19%, compared to similar properties further away. In Britain, the picture is more mixed in terms of light rail attracting premium prices for adjacent properties. In Croydon, the additional value created by proximity to light rail was found to be 10%, in Manchester 12%, and in Nottingham 15%.

3.7 Meeting Civic and Environmental Objectives

There is no doubt that a new light rail system can raise significantly the self-image of a city and its perception by outsiders. One measure of this is an analysis of tourist postcards. In cities like Amsterdam, Toronto, and Zurich, light rail is a major feature of the city postcards. London’s double-deck red buses are similarly iconic worldwide. Where increasingly retail shops and other establishments are branches of international companies, the unique personality that light rail confers on cities is now an important civic icon and under the control of local people. How important this is to reinforcing cityhood
can also be measured by the everyday use made of the services. Even with high car ownership, such light rail systems will be used by virtually everyone, with the usual distribution between frequency of use and percentage of population: a few people use light rail intensely, a few never at all, and most use light rail sometimes.

Most developed countries are now committed to reducing greenhouse gas emissions under the Kyoto Treaty and subsequent agreements. Electrically powered light rail can make an important contribution to city environments. This is especially so if car trips are diverted. If the electricity comes from renewable generation, then the light rail system will reduce both fossil fuel consumption and greenhouse gas emissions.

Light rail emits no air pollution at the point of operation in city streets. It can therefore improve the air quality of the districts through which it passes. This is especially true for the health-threatening emissions: PM$_{10}$ and NO$_x$. These emissions are in particular connected with respiratory and cardiovascular diseases. In the UK, traffic pollution kills about 45,000 people annually, compared to 3000 killed in road traffic crashes.

Finally, light rail is significantly quieter than internal-combustion-powered modes of transport. Urban noise pollution has been cited as a problem by the World Health Organization. This is both a health problem and degrades the urban social environment. The World Health Organization specifies 55 dBA external noise as the maximum to allow social conversation in city streets. Many busy roads have noise levels greater than 70 dBA, which makes conversation difficult or impossible.

There are many examples of light rail vehicles operating through pedestrianized precincts (Figure 3.11), where other modes of transport would be antisocial. It is difficult to assign a value to the ability of light rail to improve both civic image and prestige. At the same time, it offers real improvements in the quality of life for citizens, both as a means of transport and as a good neighbor. Unfortunately, none of this will be reflected directly
in the finances of the system, but it can be an important influence in obtaining the required municipal support and legal approvals. It also can be important in the vital business of attracting inward investment for industry, commerce, or housing, where a city’s image can be a major factor in attracting investors (and their spouses).

All the above provides strong justifications for the promoters of light rail to undertake full and genuine public consultation, as discussed in Section 3.1. A city that inherits a new light rail system which has not involved the demolition of property or the disruption of communities during construction will have willing supporters who likely will be regular riders.

### 3.8 Freight on Light Rail

Historically, many light rail systems carried freight, from parcels on streetcars to dedicated freight cars. Some current light rail systems also carry freight. At the high end, where light rail shares railroad tracks, as in San Diego, regular locomotive-hauled freight trains operate overnight, when the light rail service is suspended. Similarly, many of the old Comecon countries used city streetcar tracks to allow the movement of one or more rail freight wagons, between mainline sidings and factories and distribution depots. Usually small electric locomotives haul the wagons.

More recently, old tramcars have been converted to carry dedicated freight containers in Dresden (Streeter 2009). This CARGO service is an initiative from Volkswagen to link three factories in the city with a merry-go-round service using the streetcar tracks and carrying pallets of parts. This saves an estimated 200 truck movements per day in Dresden. Carrying freight in secure wheeled cages is also practical with low-floor light rail vehicles and level boarding. Such movements would allow local shops to be serviced without the need for trucks parking in the street, reducing traffic congestion and air pollution. Such a freight service would be combined with consolidation centers as proposed by Anderson (2009). Clearly, careful planning of access to any freight depots is required, as is access where wheeled cages are expected to be loaded and unloaded.