IMPLEMENTATION OF NEW PUBLIC TRANSPORT SYSTEMS: THE LIECHTENSTEIN AUTOMATED PEOPLE MOVER CASE STUDY

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ABSTRACT

The paper examines the criteria needed for successfully implementing new public transport systems and presents a migration strategy for introducing new public transport systems. The research is based on a case study of a proposed automatic people mover (APM) system completed for the Principality of Liechtenstein. An earlier study had shown that an APM system could be feasible for the particular geographic and economic conditions in Liechtenstein. This case study compared several different alternative traditional and new public transport systems including APM for the proposed route. The study found that the proposed APM system would have extremely high costs and would not achieve Liechtenstein's objective of significantly increasing public transport mode split. A key problem was the unwillingness of Liechtenstein to introduce disincentives for private automobile travel. The case study also identified a migration strategy that could be used by Liechtenstein to improve its existing public transport system in a manner that enables it to implement the APM system in the future. The paper describes the case study and presents general conclusions that can be made about new public transport based on the study results.

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1 INTRODUCTION

By the late 1950s public transport systems were facing a growing crisis. Patronage was declining due to rising automobile ownership and declining service quality brought about partly by years of disinvestment (and, in Europe, the destruction caused in WWII).

During the 1960s and 1970s, several new fixed guideway public transport (NPT) systems were developed and implemented in an attempt to increase transit patronage. These included new monorail systems, magnetic levitation trains, hover-cushion vehicles as well as further development of conventional systems including automated cable cars or guided busses. Often these systems also included new technology such as automation and linear motors.

Today it is clear that none of these new systems have been truly successful in the sense that they have not been significantly extended and the specific new technologies have not been built in other cities. Indeed, promotional literature from the 1960s shows cities criss-crossed with monorails and automated systems. Why didn't this happen? There are three main reasons: cost, network and technology. Specifically:

- Introducing a new guideway transit system is more expensive than conventional public transport (or their costs were too high compared with their benefits). In other words many public transport problems could be addressed less expensively by simply improving conventional systems. This is especially problematic for new transit systems because network size is a key success factor for all public transport systems: since the new systems were not enlarged, they didn't reach the critical mass, and therefore they remained expensive – a vicious circle!
- Second, the new guideway transit systems could not be easily integrated into existing public transport networks. A new system generates new transfer points, where the new system's travel time benefits are lost reducing its attractiveness.
- Finally, many NPT systems were driven by the technical innovation process rather than an analysis of transportation demands and requirements. Technically-driven development processes are more often than not a disappointment, unless the technical solution meets an existing market need. Using new technology also increased costs and created difficult phasing-in periods when service quality was compromised.

Many cities and regions experimented with different NPT systems and technologies for traditional transport needs. A good example is the San Francisco Bay Area Rapid Transit (BART). While BART provides excellent service it suffers from all three of the typical NPT problems: high cost, difficulty integrating with other public transport networks (e.g. AC Transit bus service) and the focus on new technology. [1]

In other cases NPT systems were developed to serve markets where conventional public transport systems were not feasible or optimal (e.g. special transport demands or unique topographic conditions). One promising idea combined several new technologies into an automated people mover (APM) system. However, with the exception of special cases such as airports, APMs have not been widely used in traditional public transport markets for the reasons outlined above.

But what would happen, if a new public transport system were needed in a city without an existing guideway transit system? In Europe such a situation occurs very rarely because there are few rapidly developing cities without traditional rail networks. However, driven by its particular geography and development situation, the principality of Liechtenstein presents such a case. Furthermore, Liechtenstein's economy is strong enough to support construction and operation of a new guideway based public transport system. This research describes the process of evaluating the potential for building a NPT system in Liechtenstein.

Liechtenstein Case Study

Liechtenstein is located between Switzerland and Austria in the Alpine-Rhine Valley. It is a small country (160.4 km²) with a population of 34,905 (2005). [2] Due to its geography, Liechtenstein consists of a chain of villages located along a single main roadway. The mountains and Rhine River limit the areas available for urban development resulting in a long and narrow development corridor accessible from the main roadway.

Liechtenstein is undergoing rapid economic growth, and since all the jobs are located along the main roadway, traffic congestion is becoming a significant problem. Liechtenstein’s public transport is a bus-based system; as traffic congestion increases buses are increasingly being caught in congestion reducing the system’s speed and reliability.

For historical reasons, Liechtenstein’s capital, Vaduz, is not located on a railway line. Instead, the main railroad leading from Zurich to Vienna passes on the opposite bank of the Rhine River. The only railway station in Liechtenstein is in the village of Schaan in the northern part of the country. However, the Zurich-Vienna rail line still plays an important role in the Principality’s transport network by connecting the densely populated Swiss and Austrian regions to jobs in Liechtenstein. Feeder buses connect the railway stations to jobs.

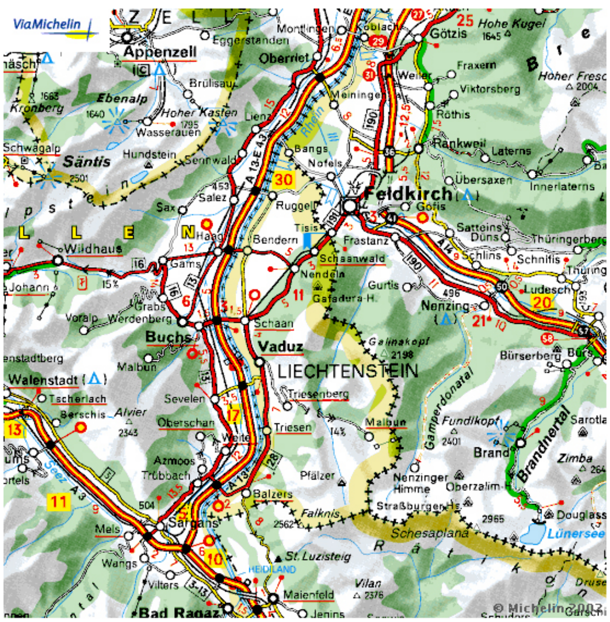

Figure 1: Map of Liechtenstein

Research Methodology

In order to address growing traffic congestion, the Principality of Liechtenstein prepared an initial study of several different new public transport systems during 2003. [3] The proposed Liechtenstein NPT would follow the main axis from Sargans (the Swiss railway station) in the south to Feldkirch (the Austrian railway station) in the north. It would be approximately 30-km long and cost between $820 million – $1.27 billion.

The initial study results were promising and therefore Liechtenstein asked the ETH Zurich’s Institute for Transport Planning and Systems (IVT) to complete a more detailed study of new public transport system requirements and to prepare an analysis of system operations. [4] The IVT study considered the following:

- NPT system operational characteristics (including speed, frequency and capacity);
- Strategies for integrating an NPT system into the existing public transport system and increasing the system's usefulness;
- NPT system alternatives and supplemental measures to encourage NPT system use (e.g. parking restrictions);
- Construction alternatives including staged construction and addressing the need to preserve historic buildings and landscapes, especially within historic villages; and
- Potential patronage, revenues and costs.

The IVT study gave special attention to developing a migration strategy from today's public transport system to a fully equipped new network, as well as to the system's economical and political aspects. Special focus was given to these issues, since experience shows that these points may create insurmountable obstacles to NPT implementation. This paper describes main results of the research project; more details are available in the full study report. [4]

2. TRAFFIC DEMAND AND TRANSPORT POLICY OBJECTIVES

Existing Conditions

Liechtenstein has approximately 35,000 inhabitants and 30,000 work places. Most of the country's development is located in a chain of villages running through a valley bordered on the west by the Rhine and on the East by the Alps. Liechtenstein's economy is based on high tech industry and financial services, and is growing rapidly. Employment is projected to grow to 44,000 by 2040. [5]

Liechtenstein is a small country with very limited potential for additional residential development. Therefore, the projected rapid economic growth is expected to increase congestion and create serious traffic problems, since most of the new workers will come from the neighboring regions of Austria and Switzerland. The projected increase in commuters is presented in Table 1.

Table 1: Population and Employment Projections in Liechtenstein [5]

	1990	2000	2005	2025	2040
Residents	29,000	33,500	34,900	41,900	47,500
Workers	20,000	27,000	30,170	37,500	44,700
Commuters	6,885	11,192	14,503	18,000	23,000

Future Challenge

As shown in Table 2, the public transport mode split in Liechtenstein today is only about 13%, although service is operated frequently and fares are relatively low. One reason for this relatively low public transport mode split is the high number of private automobiles (approximately 31,000 cars for 35,000 inhabitants), due to the country's high median income. Another reason is that (until now) traffic congestion has been relatively limited and there are few parking problems. Table 2 also shows the expected increase in transport demand, given the high expected growth rates. The data in Table 2 clearly show that the road system will not be able to meet the projected demand and, if nothing is done, traffic congestion could hinder expected economic development.

An interesting aspect of Liechtenstein's transport demand is that over 50% of traffic consists of work trips [5]. This high share of travelers in a traditional public transport market means that Liechtenstein could be a good candidate for an NPT system.

Table 2: Liechtenstein Transport Demand 2001 and Forecast 2025. [3]

Year	Private Automobile: Person-km/Day	Public Transport: Passenger-km/Day	Total Transport/ Day (km)	Public Transport Share
2001	915,000	131,000	1,046,000	13%*
2025	1,456,750	214,000	1,670,750	13%*

*Includes rail passengers between Buchs and Feldkirch; without these passengers the public transport share is approximately 10% (2001) and 11% (2025).

Transport Policy Objectives

The citizens of Liechtenstein are opposed to building new roads and expanding the existing roads even though transport demand forecasts show that the road system will not be sufficient to meet demand in 2025. Therefore, one of the country's key transport policy objectives is to increase the use of public transport. However, Liechtenstein also hopes to do this without imposing artificial constraints on automobile traffic (e.g. parking limitations, congestion pricing). [6] In order to increase public transport mode share without imposing artificial constraints Liechtenstein must significantly improve the quality of public transport. Liechtenstein is considering NPT solutions for the following reasons:

- Liechtenstein must significantly improve transit service quality to increase public transport mode share without imposing restrictions on auto traffic.
- The existing bus system has insufficient capacity to meet projected demand.
- The quality of existing bus service is increasingly suffering from traffic congestion, so developing a public transport infrastructure independent from road traffic is needed.
- Acceptance of public transport depends on the system image.
- High frequency bus service will increase personal costs.

For these reasons, and because there is a concentration of relatively high demand on a single axis, Liechtenstein may be an attractive market for implementing a new public transport system.

3. NTP SYSTEM PLANNING AND MIGRATION STRATEGIES

The IVT research study distinguished between the following two types of public transport systems:

- ***Conventional public transport systems*** are bus and railway, but also include many refinements of these traditional modes such as bus rapid transit, high-speed rail, light rail and metro systems.
- ***Unconventional public transport systems*** are special technical solutions including monorails, guided bus systems, "Tram sur Pneu", etc.

As will be discussed in Section 5 (Public Transport Migration Strategy), in some cases an unconventional system represents continued development of a conventional system (e.g. bus rapid transit with guided buses).

A "new" public transport system is defined as introducing a new guideway-based public transport system (either conventional or unconventional) to a region which does not currently have a guideway system. An important part of this definition is the idea that these systems are more than just short shuttles for airports or amusement parks, they are part of fully functioning public transport networks.

In the case of Liechtenstein the proposed NPT would be an unconventional public transport system, specifically an automated people mover (APM). [3]

Since new public transport systems are simply applications of new technology, proposed NPTs should be analyzed and planned the same way as any public transport system. However, they must include a full analysis of how they interface with the existing public transport system, a step that is often neglected in the excitement of developing new technological solutions.

A successful public transport development process is customer driven. This means that any changes or additions to the public transport network must be optimally linked to the existing network and that NPT should only be considered if it has a better cost/benefit ratio than improving the existing system. Figure 2 presents the public transport system development process used in this study.

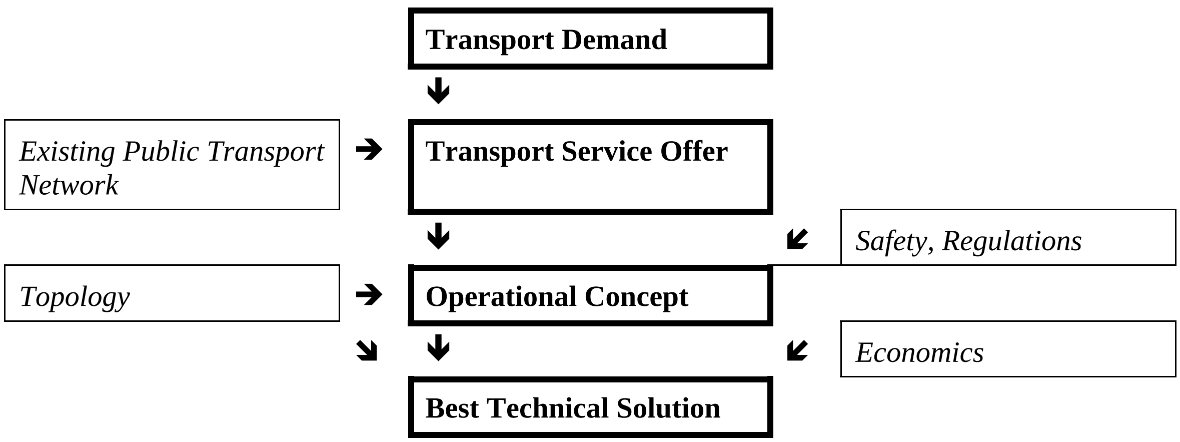

Figure 2: Public transport system development process.

Migration Strategy

Migration is the process of implementing the new technology (i.e. building the new transport system). Fully considering migration is extremely important in building new public transport systems where there are large uncertainties in market demand (such as in Liechtenstein), and because capital costs for these systems can be extremely high. A particular problem with new technology projects is that they need to be finished to be useful.

A well defined migration strategy can help reduce the risk of investing too early and losing money, or investing too late and losing market share. In this study the authors applied the following migration principles:

1. Large investments should be postponed as long as possible. This enables planners to reduce risks by carefully observing emerging transport needs and optimizing system design to meet actual needs.
2. Each stage of the project should make sense. This means that if the project cannot be completed (or the market changes) at least there will be a usable segment.
3. Each stage should generate revenue. The sooner the project generates revenue, the higher the project's overall profitability.

These migration principles take into consideration that building an NPT takes a long time. Since conditions may change during this time, the principles help insure that the NPT can be useful to the region even if the NPT is not fully completed.

4. LIECHTENSTEIN CASE STUDY

Liechtenstein completed its initial analysis of an NPT in 2004. The purpose of the IVT study was to prepare a more detailed analysis of the proposed system and to examine various migration strategies for its implementation. A fundamental part of the IVT analysis was to examine alternatives to the proposed NPT to determine if any of them could better meet the country's needs. In other words, could a lower cost alternative achieve the positive effects of a new transport system with fewer problems? This section presents a general description of the alternatives considered for Liechtenstein and then describes the specific alternatives as they would be applied in Liechtenstein.

Public Transport Alternatives

Today's public transport market provides an unlimited number of different alternatives. Each alternative has its own specific market niche where it competes with a limited number of other alternatives. In general these niches are defined by technical criteria such as transport demand and specific local conditions such as topography.

In the case of Liechtenstein's market (relatively strong demand concentrated on a single axis) the following public transport modes are most appropriate:

- Bus – Bus transport is flexible as well as being inexpensive to build and operate. Bus lines may be easily changed and adapted to new needs. However, buses have a poor public image and studies have shown that other means of transport could attract higher patronage. Liechtenstein currently has a bus-based public transport system.
- Guided Bus – After years of development a new generation of guided buses are in commercial service in several French cities. [7] The main advantages of guided buses are that they require a smaller physical clearance and that they convey a better image. The bus guidance system can be used on the entire route or only on segments (for example in the city center). If guidance systems are used on the entire route it is possible to use much longer vehicles (up to 40 m), this increases capacity but reduces flexibility. Investment costs for guided bus infrastructure are much lower than for light rail.
- Surface Light Rail – Surface based light rail systems offer high capacity and frequency, but costs are relatively high. In order to operate efficiently these systems require exclusive right of way.
- Elevated Rail – Elevated rail systems including monorails can offer high capacity and frequency although at a higher cost than surface rail. Since they operate on completely separated guideway they can be run automatically. The ground space needed is small (pillars and station access), but they have a significant visual impact on traditional cityscapes. [8]
- Underground Rail – Underground rail systems offer a high capacity and may be built with minimal impacts even in densely developed traditional town centers. But costs are extremely high, even in the case of systems with small clearances such as the French VAL system. Underground rail systems can also be run automatically. [9]
- Hybrid Light Rail – Hybrid light rail systems operate like streetcars in city centers and use traditional railroads outside centers (e.g. Karlsruhe Germany). These systems combine some of the better qualities of regional rail and light rail into a single transit service. Their cost varies considerably depending on the specific design. [10]

A key design feature in all these public transport systems is the right of way used, or more particularly, whether the right of way is exclusive or shared. The question of exclusive versus shared right of way determines the system's capacity as well as its service quality. [11] Exclusive rights of way always provide the highest public transport capacity and service quality, but are more expensive to build.

Elevated and underground public transport systems are, by definition, exclusive right of way. Exclusive lanes can also be built on the surface, but they take more land than shared lanes. Shared lanes have the advantage of allowing public transport to run through the narrow parts of the cities and their infrastructure costs may also be shared with other forms of transport. The main disadvantages of shared lanes are reduced capacity and speed as well the high probability of disruptions and delays.

From a transport planning viewpoint, the distinction between exclusive and shared right of way is as important as the choice of public transport mode because, with exclusive right of way, buses can offer service levels and capacity similar to some light rail systems. Conversely, the speed and reliability of a light rail line operating in a shared lane will not be much better than that of a bus line. Exclusive lanes for buses or rail systems can be created in different ways:

- A separate lane can be marked on the street. In normal operation this avoids disturbances, but in emergencies it can be used by others.
- A separate road or track can be built; this eliminates all external influences on operations, but requires more space.
- Elevated or underground structures can be built; although these have very high costs.

In the case of Liechtenstein, it was clear, based on the existing conditions and expected traffic growth, that some amount of exclusive right of way would be required to create an attractive high quality public transport system. Therefore exclusive right of way became a key part of the alternative development process.

Liechtenstein Public Transport Network Alternatives

Principles

The following three questions were used to help develop the Liechtenstein public transport network alternatives:

1. Which mode of transport is best suited for Liechtenstein’s long term needs?
2. Where and how should an exclusive transit right of way be built?
3. What is the best migration strategy for implementing the recommended transport solution?

Five main alternatives were developed. In all alternatives the public transport networks had to fully meet all Liechtenstein’s mobility needs (i.e. at the local, regional and long distance levels), the public transport modes had to be connected in order to guarantee integrated transport chains, and all network designs had to be dimensioned to meet expected demand.

In all alternatives the public transport was required to pass through the city center of Vaduz (the main destination). Since Vaduz is a traditional city there is not much space available for roadways and providing an exclusive lane for public transport meant that a new road had to be created around the city for private transport (this was not an idea that was easy to communicate to decision-makers).

Once the alternatives had been developed they were evaluated and compared based on projected patronage, costs and impacts. The alternatives are illustrated schematically in Figure 3 and described in the following paragraphs.

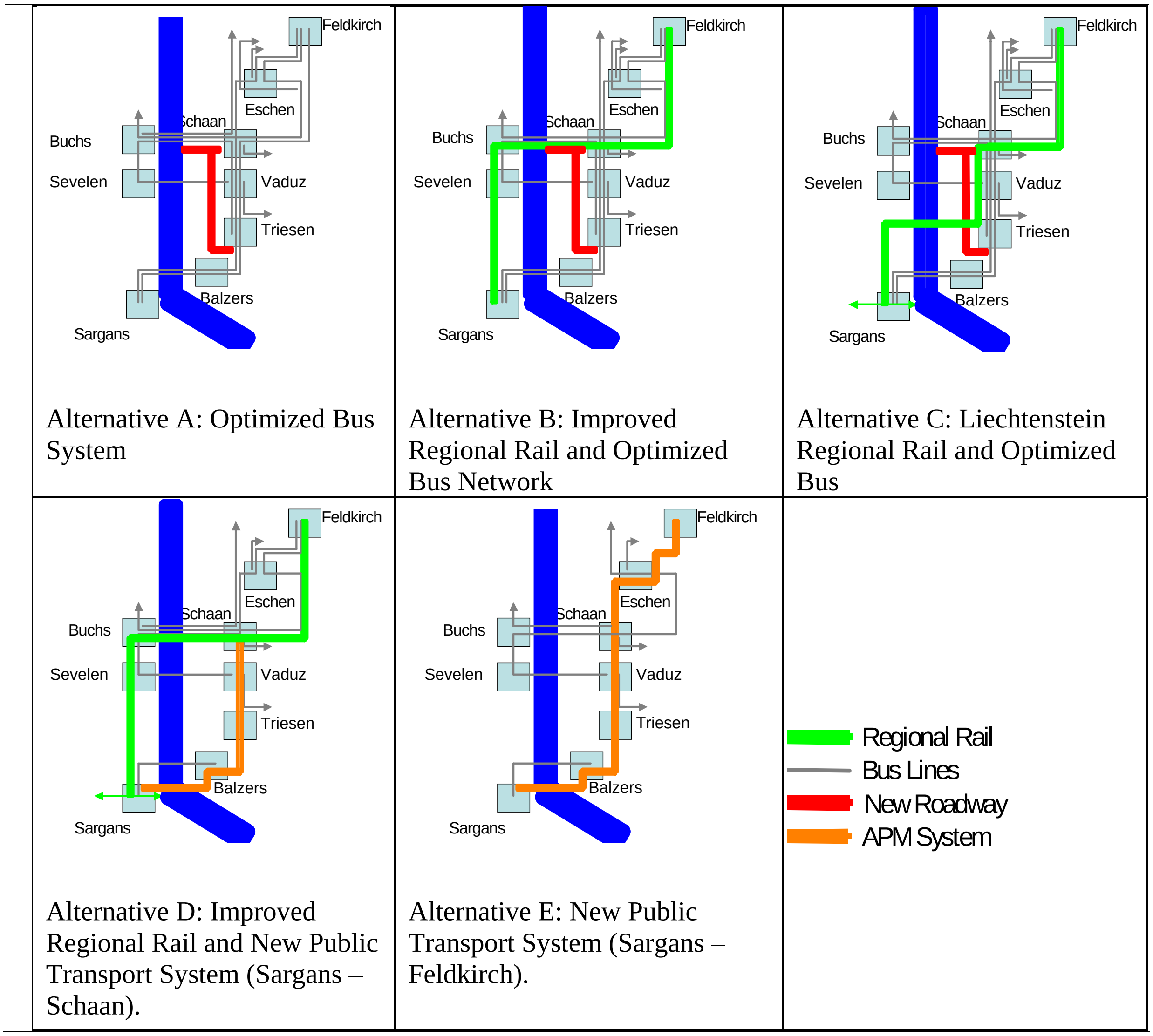

Figure 3: Schematic Diagram of Alternatives; arrows show ongoing lines

Alternative A: Existing Bus Network Optimization

Alternative A consists of optimizing the existing bus network. This alternative offers the most flexibility and the lowest operating costs. The main investment is the new bypass road around Vaduz for private transport. In this alternative bus service would be significantly increased (10-minute headways on the main axis) over existing conditions. Additional improvements would be made to improve service quality, for example express buses would be added from Sargans to Vaduz to improve long distance connections to rail. In this way, Alternative A shows the maximum market potential of the existing system.

Alternative B: Upgrade Regional Rail Service and Optimize Bus Network

Alternative B consists of upgrading the existing regional rail network (to better serve regional transport flows, especially for the commuters coming from Switzerland and Austria) and optimizing the bus network similar to that in Alternative A. In this alternative, rail would be upgraded to an S-Bahn-type system with half hourly schedules and the bus system would be used to provide feeder and local services.

Alternative C: New Liechtenstein Rail Link and Bus Network Optimization

Alternative C consists of building a new railroad link from Sargans (Switzerland) over the Rhine River through Liechtenstein's main valley to Feldkirch (Austria). This new line would provide S-Bahn type direct train services to Liechtenstein's main employment centers. It would reduce travel time significantly and many commuters wouldn't need to transfer to buses. The bus system would be reduced compared to Alternative B. Two sub-alternatives were considered; C-1 would build a separate roadway bypass of Vaduz, while C-2 would not build the bypass.

Alternative D: Upgrade Regional Rail Service and Build Sargans and Schaan NPT System

Alternative D consists of upgrading the regional rail network service similar to that in Alternative B and building an NPT through Liechtenstein between Sargans and Schaan. In this alternative, all the most heavily used transport axes would be equipped with a high performance public transport system. The NPT would cross the city of Vaduz on an elevated structure so that a new roadway bypass of Vaduz would not be needed. The NPT would be an automated people mover (APM) system.

Alternative E: Build Sargans – Schaan Regional NPT

Alternative E consists of building an NPT between Sargans and Feldkirch. This NPT would then serve nearly all Liechtenstein's mobility needs. Additional bus service would be provided to connect parts of Switzerland to the NPT and for smaller traffic flows within Liechtenstein. The NPT would be an APM system. Two sub-alternatives were tested; E-1 assumed the existing regional rail service and E-2 tested improved regional service (same as Alternative B).

5. ALTERNATIVE EVALUATION

Once the alternatives were defined they were evaluated using a transport demand model and other analysis tools. This section presents the evaluation results.

Transport Demand Analysis

One of Liechtenstein's main transport policy goals is to shift passengers from private to public transport in order to preserve the high quality of life and long term economic growth. The transport model VISUM/VISEM was used to evaluate the different alternatives quantitatively. The model takes into account the following:

- Road network, distances, travel times
- Public transport supply (networks, lines, stops, timetables, headways)
- Observed demand on private traffic
- Observed demand on public transport
- Number of inhabitants and age
- Number of employees, schools
- Growth rates derived from the general forecast (Table 1)
- Number of cars per inhabitant

These data were used to create a complete O-D-matrix of transport demand, which was then used to estimate mode split for each alternative. To calculate the traffic assignment as accurately as possible, every municipality was divided into several different traffic zones. The model was used to estimate the transportation quantity in passenger-kilometers for each alternative. On the base of these transport quantities the modal split between public and individual transport has been calculated. Figure 4 summarizes the analysis results.

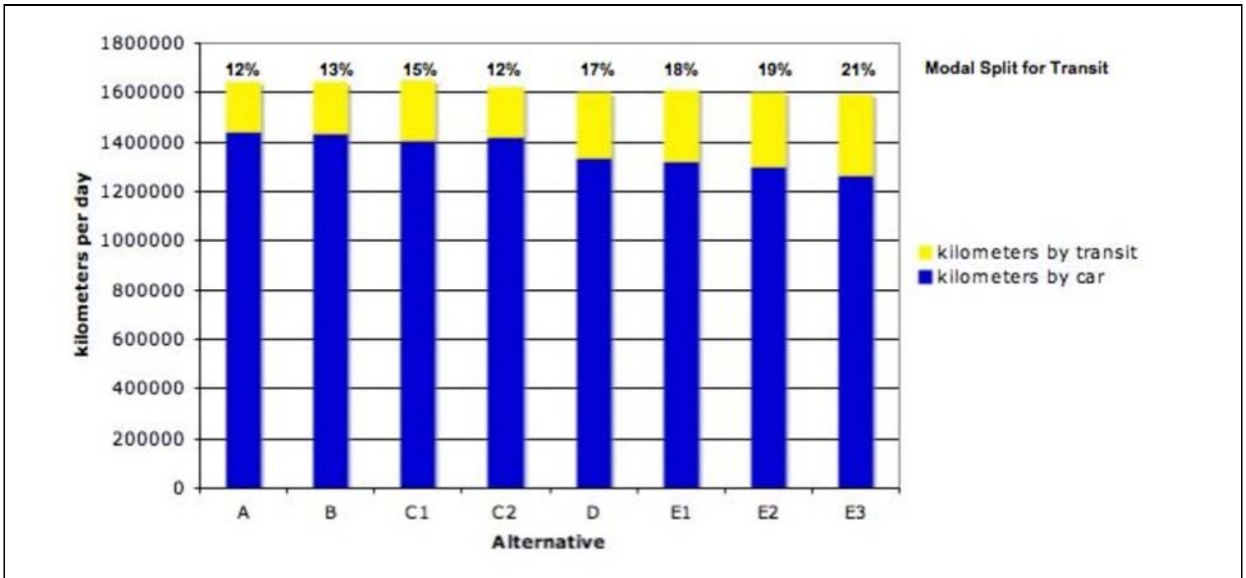

Figure 4: Transport Demand Liechtenstein 2025.

Alternative Technology, Market and Cost Evaluation

In addition to the patronage forecasting analysis, the alternatives were evaluated using other criteria including market impact (i.e. shift in modal split, quality of service for users), capital and operating costs, migration ability, technology, political and financial feasibility, construction feasibility, and environmental compatibility. [4] In all cases the alternatives were found to be feasible, however the alternatives with elevated guideways were not easily compatible with the traditional townscape. [8] Table 3 summarizes results of the analysis for key criteria.

As shown in Table 3, Liechtenstein's original proposal to build an automated people mover would be very expensive without having clear market advantages. But it is also true that all the alternatives would be expensive, even the more modest ones. So the question becomes how far should Liechtenstein go in improving its public transport system. The answer was developed considering, (1) the effectiveness of the alternatives in meeting the Liechtenstein's goal of shifting demand to public transport; and (2) the time dynamics, in other words identifying feasible migration strategies. This analysis is outlined in the following sections.

Table 3: Liechtenstein NPT Study: Alternative Evaluation Summary

Alternative	Existing	A	B	C1	C2	D	E
Alternative Short Description	Existing (1)	Improved Bus System	Regional Rail Improved + Improved Bus	New Regional Rail + Improved Bus	New Regional Rail + Improved Bus	Regional Rail Improved + NPT System	Full NPT System
Accessibility	Very Good	Good	Good	Good	Good	Fair	Fair
Availability	Fair	Good	Good	Good	Good	Good	Very Good
Mean speed	Poor	Fair	Fair	Good	Fair	Fair	Good
Reliability	Fair	Good	Good to Very Good	Very Good	Good (2)	Very Good	Very Good
Direct Trips (transfers?)	Medium	Few	Medium	Medium	Medium	Medium	Medium
Modal Split % Public Trans.	10	12	13	15	12	17	18
Migration Strategy	None	Very Good	Good	Fair	Fair	Poor	Poor
Investment Cost Million $ (3)	0	210	210	550	340	510	820 – 1270
Annual Operate Cost M, $ (3)	16	32	42	49	40	57	67 – 82 (4)

Poor = Does not satisfy the criteria.
Fair = Satisfies criteria at the most basic level.
Medium = More than satisfies the criteria.

(1) System design 0 represents the actual situation and is based upon the figures of 2001
(2) Alternative C2 experiences traffic disturbances on main road.
(3) Including costs for new main road around Vaduz.
(4) Depends upon the length of the Feldkirch tunnel.

Alternative Effectiveness Analysis (Public Transport Mode Split vs. Cost)

The effectiveness of each alternative was estimated by comparing the alternative's annual costs to its public transport modal split. This analysis is presented in Figure 5. This figure shows that operating costs rise steeply from scheme to scheme whereas modal split goes up only slowly. The most unfavorable step is from D to E, where modal split increases very slightly, but annual costs increase significantly.

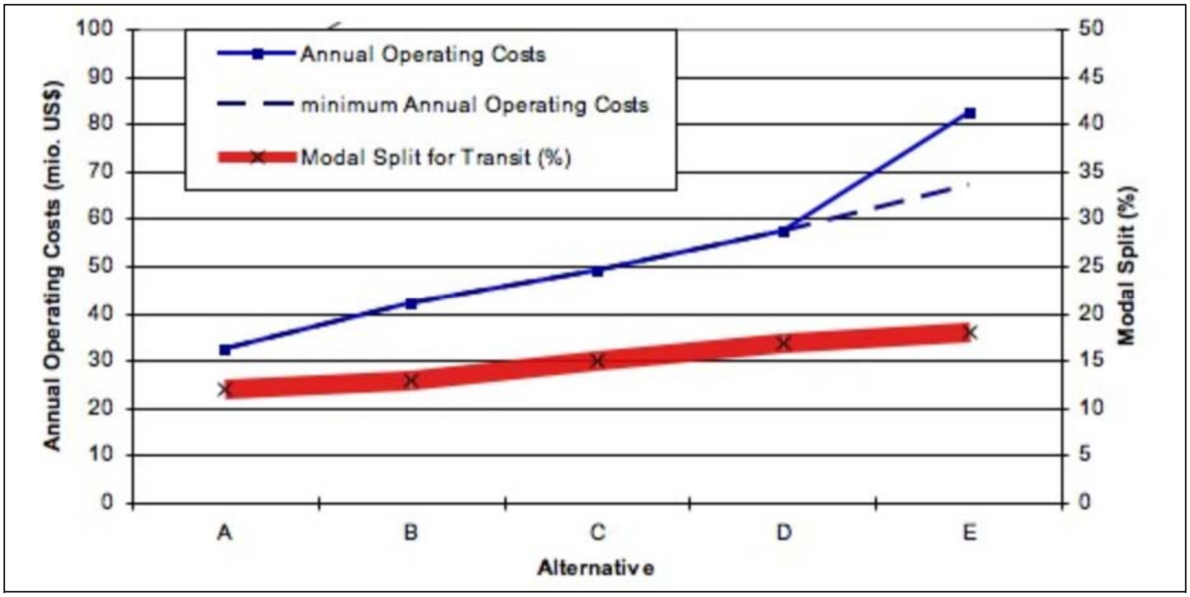

Figure 5: Annual Operating Costs versus Public Transport Mode Split.

To make the comparison even more clear, the ratio between the annual costs and the public transport modal share was calculated. Table 4 shows that the marginal cost of attracting additional market share to public transport rises significantly between alternatives D and E. In other words modal share on public transport may be increased at relatively low annual costs up to about 17% (alternative D), higher shares are only possible with significantly higher costs.

Table 4: Annual costs per percent of Public Transport Mode Split.

Design scheme	Annual costs / % of mode split PT [M $/%]
0	1.6
A	2.7
B	3.2
C	3.3
D	3.4
E	3.7 – 4.6

Finally, it should be noted that these results show that it is not possible to achieve a large modal shift simply by improving public transport. In other words, to increase public transport use, it is necessary to also adopt some measures to reduce automobile-based transport.

Public Transport Migration Strategy for Liechtenstein

As discussed earlier, Liechtenstein's growth rates are high, but they depend on various internal and external influences and it is uncertain whether development will continue as expected.

Therefore, the proposed plan for improving Liechtenstein's public transport system must include a migration strategy that both reduces risk and ensures that each step makes sense. Such a strategy will include the following elements:

- significantly increases public transport's market share quickly;
- may be realized on a step by step basis and at bearable costs; and,
- leaves as many options as possible available for future decision-making.

The first step in identifying a migration strategy for Liechtenstein was to lay-out all the possible migration paths starting from the existing situation. Figure 6 illustrates possible migration paths for each mode of transport. The vertical axis plots technology level (from less advanced to more advanced) and the horizontal axis plots time from the existing state to two stages of future growth.

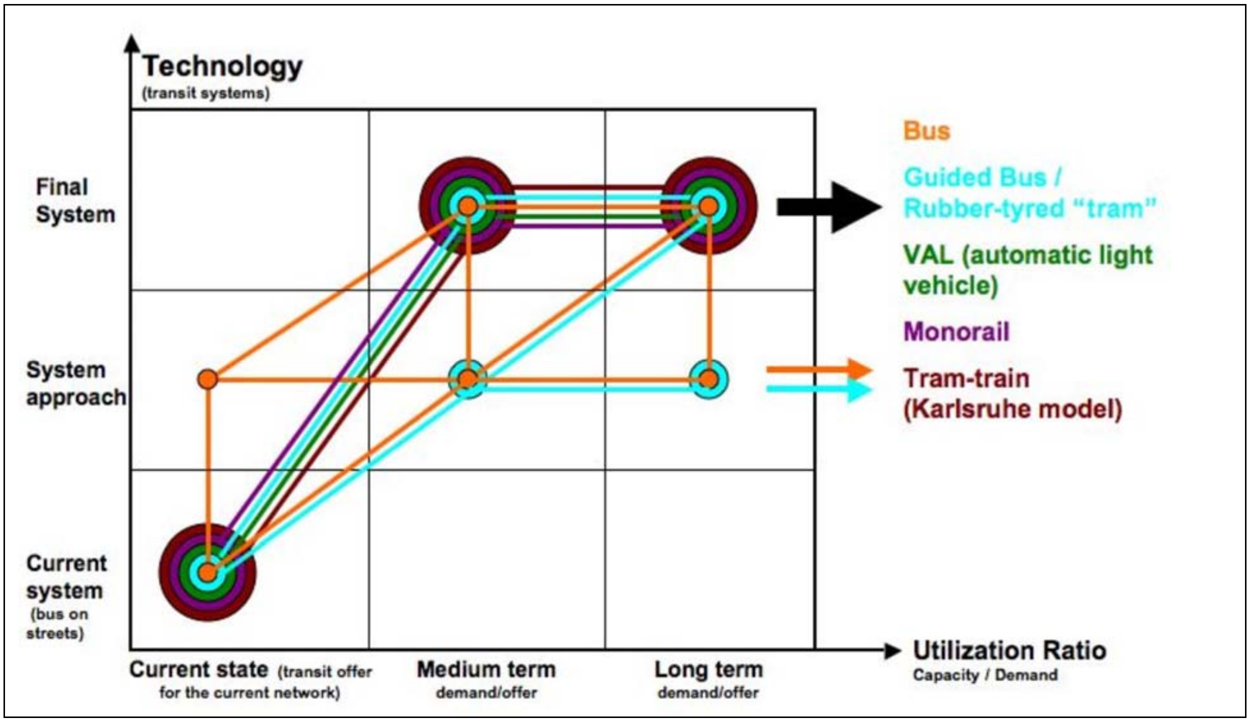

Figure 6: Migration paths for new public transport systems.

As shown in Figure 6, the immediate implementation of new technology such as guided bus, and more capital intensive underground and elevated rail lines, would require that Liechtenstein make a significant leap in technology. In contrast it would be possible to reach the same level of technology following a more gradual path. For example, the existing bus system could be improved by gradually increasing the amount of dedicated bus lanes (starting in places with the worst traffic congestion). Once a significant share of the bus route is in dedicated lanes, this infrastructure could be converted into a new public transport system (e.g. light rail, APM) relatively quickly and efficiently.

Following a more gradual path makes it possible to limit the risks created by the uncertain economic development forecasts and to ensure that each small step of system improvement would be useful. If development forecasts are not met, investments for the further steps could be stopped without creating huge sunk costs.

6. CONCLUSIONS AND RECOMMENDATIONS

New public transport (NPT) systems are defined as new guideway transport systems introduced into a city/region. NPT systems often take the form of new technology (e.g. automated people movers). However, many new technology NPT systems are unsuccessful in the sense that they are not extended or built in other cities. The Liechtenstein case study provided an opportunity to analyze this result.

The Liechtenstein case study was unique for Europe because Liechtenstein is facing rapid economic growth and has no existing guideway transit system. The region's geography, which focuses development in a single corridor, also makes it an idea market for an NPT system. The study evaluated five main alternatives: an improved bus network, an improved bus network and regional rail system, a NPT rail system through Liechtenstein (new regional rail line), and two NPT automated people mover (APM) alternatives. The results showed that all the alternatives would be extremely expensive and, without measures to reduce automobile use, would not significantly improve public transport mode split.

However, the study also showed that Liechtenstein must improve its public transport system if it is to preserve its quality of life and maintain economic growth. Therefore the study identified a migration strategy that consists of improving the bus network in stages with the idea that an NPT type system could be implemented in the future when demand increases. In summary, the authors state the following general conclusions:

- Successful implementation of NPT systems strongly depends on the region's existing public transport system.
- In cases where there is no existing public transport system, it is much easier to implement an NPT system. In these cases, the decision whether to implement an NPT depends on an economic and service quality comparison.
- In cases where there is an existing public transport system – in the form of a network, NPT has the best possibility for implementation as the last stage of a migration process for a public transport line or network.

Clearly NPT systems make sense in certain situations, specifically when special problems or travel demands cannot be solved with conventional public transport systems, but they are not the general solution for public transport problems.

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