PRT – Personal Rapid Transport – and a Telenor Involvement

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Telenor, the incumbent telco and an ICT corporation, is at the time of writing active in forming a consortium to prequalify for a PPP (public private partnership) contract, actively seeking to solve the special technologial and other challenges to be solved to have a PRT system built in the area. Why?

A group of Telenor employees on a Master's degree study in telecom strategy 2001–2002 used their project work within ITS (Intelligent Transport Systems) to carry out an analysis of the PRT concept and its feasibility, and to explore the business opportunities involved. Also, in parallel and close cooperation, a feasability study for the construction and operation of a PRT system in the Lysaker – Fornebu area was carried out for the Telenor management.

This paper presents the main findings and the present status of the two projects as of October 2002. The authors were engaged in one or both of them.

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The Case: An Automatic Elevated Public Transport System to be Built

The Lysaker area (see Figure 1) is a bottleneck along the so-called West corridor in/out of Oslo, with offices housing about 20,000 employees in a compact belt along the motorway. Public transportation in the area, as well as on the attached peninsula, was since long a concern for the public authorities.

In 1996 these daily jams also became relevant to Telenor, as Telenor decided to build its new headquarter on the peninsula: There, on the site of the old Oslo airport, Fornebu, the ambitions are to develop an ICT industrial center and a new dwelling area. Telenor has now moved in. A transportation solution was of course a prerequisite and Telenor has been an active partner to the authorities in finding environmentally friendly transport solutions untill a rail-based public transport system is operative in 2006.

For the businesses involved as well as for the local and regional government, the ambitions have been high as to giving the entire development a profile of being innovative and environmentally friendly. The development of the Fornebu area has thus represented a unique opportunity to bring forward innovation in all areas and levels, and still does. Correspondingly, the regulating authorities have demanded the development to be "environmentally sustainable"; i.e. strong measures should be taken to avoid pollution and to find energy saving means. There has been, and still is, extensive cooperation between the public authorities and the local property developers, employers and property owners to develop good solutions for the area. As the first large employer moving into the area, Telenor easily gets the role of locomotive in this process.

The new traffic ensuing from the development, with around 36,000 new travellers a day in/out

Figure 1 The West corridor at Lysaker, the peninsula with Telenor's new headquarters, and the suggested APM track

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as well as within the area, will add to the already substantial traffic jams along the Oslo West transport corridor, were private cars come to a nearly complete standstill in rush hours. Various measures and restrictions have been implemented such that a substantial percentage of the employees and other travellers to and from the area will have to go by public transport.

Accordingly, a new public transport system had to be developed, either by extensions of existing bus, tram or train lines from Lysaker and out on the peninsula, or by developing some kind of feeder system to the Lysaker terminal. The property owners and developers, such as Telenor, will all have to pay their share. Telenor is thus, although a private corporation within ICT, an evident stakeholder in the process of providing for public transport. Also, the national government has – in its quest for more innovation and local involvement – expressed its interest in having the large employers in the area actively engaged in the development and operations of the public transport solution for the area.

Over several years, the authorities have worked out noumerous white papers and studies on the various public transport alternatives. In short, the local government decided summer 2002 on an automatic elevated rail system for the area. Basically, such systems are unmanned – but otherwise conventional – tram systems shuttling back and forth on an elevated guideway. They are close to being commodity products, ranging from heavy large trains called APM (Automatic People Mover), to fairly lightweight systems for groups of some 20 people (GPM, for Group People Mover).

So, the alternative chosen is mainly a feeder system for the area, with its pivotal point at the Lysaker terminal, where trains, busses, and a future extension of the Oslo subway network meet. The political debate is still intense – both as to level of integration between the APM and the various other transport systems, and to the financing involved. In Figure 1, the red line roughly indicates the APM track as proposed in the government white papers; extensions decided by the politicians have been added in brown.

An APM feeder system runs independently of traffic jams at grade. Hence, it can move faster than trams between the stations. It can also be made small with frequent departures, or made large with departures more rare. It can be noisy or silent, and it may become more or less dominating as a new visual element in the area. In part due to automation and other technological elements and in part due to local topography, it can also be substantially cheaper than conventional tram or train extensions in investments as well as operations. Running on electricity, it would also have practically no local emissions.

The traffic development indicates that it is mandatory to find solutions – for this area as elsewhere – that are environmentally sustainable, cost efficient to the local governement and taxpayers, as well as attractive to the public.

However, a general problem of public transport is that year by year it loses ground to the private car. Together with parking restrictions and traffic jams, an APM system should be so attractive and with so smooth transfers that people would leave their car at home and travel by public transport. The white books indicate that it will be a tough task even though the alternative transport modes are not much better.

The system construction and operation will be under a PPP (Private Public Partnership) regime; i.e. with an SPC (Special Purpose Company) to build and operate the system on a 15 – 20 year contract. The terms for the PPP are not known at the time of writing. Prequalified tenderers will hand in their offers some time fall 2003, and the first section of the system is scheduled to be in operation from 2006.

A PRT System Will Do a Better Job – at Lower Costs

PRT is the acronym for Personal Rapid Transport (called "Transit" in the USA). The PRT design criteria have been developed to address what over time have become the weakest parts of public transport. Hence, the design addresses the changes in city structures, cost pictures for public transport input factors, as well as consumers' alternatives.

The concept of PRT has been refined over a period of more than 30 years, both through theory and tracks – with more or less successful tests and real installations on the way. At this stage of conceptual development, the concept of PRT includes a set of mutually dependent design criteria, which are contrary to conventional public mass transport thinking:

- The guideway has the shape of a mesh network, consisting of unidirectional rings connected with passive switches – as opposed to the "A to B and back" tram or rail line.
- Vehicles are automatically routed through the network from departure to destination with no transfers – as opposed to tram or rail systems with fixed stops and transfers between lines.
- Vehicles are small and light, for use by the individual or up to 3–5 persons, and are used

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Jan Orsteen (55) holds an MSc from the Norwegian University of Science and Technology and has done business studies at BI Norwegian School of Management. He has extensive experience from transportation planning in public service and consulting companies. At present, Jan is independent consultant in transport planning and business management after having held senior positions in the major consulting companies in Norway, such as Norconsult. He was also a founder and CEO of ViaNova, a leading company in transportation planning and related software development. Jan Orsteen has also been project manager of several studies in the transportation sector, particularly around Oslo.

Figure 2 Artist's impression of a PRT system (source: www.cities21.org)

as taxis – as opposed to large and heavy rail systems used for simultaneous transport of passengers with different departures and destinations.

- Vehicles wait at stations and depart on demand, as a taxi – as opposed to the trams' fixed schedules.
- All stops (i.e. stations) are located at side-tracks – as opposed to stations along main guideway, blocking for traffic to flow.
- Along the main tracks, vehicles run at headways down to around 1.5 seconds, and at constant speed, e.g. 40 km/h, independent of other traffic – as opposed to 15–20 km/h mean speed for trams and busses in city centers, frequently impeded by other traffic.
- Vehicles and structural elements are designed to be lightweight, and with no passenger standing – as opposed to the heavy structures resulting from the heavy "light rail" systems transport mode.

Such a system may look as in Figure 2, which shows an artist's impression. Note that such systems can be light enough to be fixed to building walls or be laid over ordinary office building floors.

Though contrary to our conceptions of mass public transport as they may seem, such systems have amazing capacities. Figure 3 shows the theoretical capacities of a PRT system guideway with headways (distance between front of vehicles) larger than frequently found on the motorways in the morning rush – at twice the speed. The table shows that as to the *theoretical* capacity of the guideway, the capacity needed for the Fornebu – Lysaker area rush hours (2,800 pass./hour) can easily be met by a PRT system, even with the taxi standard of 1.2 passengers per vehicle. However, implementations – i.e. control systems, switches, stations, public safety requirements, traffic patterns, and much more – decide to which extent the teoretical capacity of the guideway can be maintained in real operations.

Headway (secs)	**Number of passengers**				
	1	1.2	2	3	4
1.5	3600	4320	7200	10800	14400
2	2400	2880	4800	7200	9600

Figure 3 Passenger capacity per hour as function of headway and passengers per vehicle

Dag Sanne obtained his BCom from the Norwegian School of Economics and Business Administration and worked for IBM from 1968 to 1994, the last 7 years in corporate management. He has managerial experience from sales and marketing, but also from system development, technical service, administration, human resources, information and public contact. From 1991 to 1994 Dag Sanne was responsible for the down-scaling of IBM in Norway while also taking care of IBM's commitments in the 1994 Lillehammer Olympics. In 1992 he took the lead in establishing Birkebeinerlaugets Bedriftsutvikling, where he went on to become chairman and, after leaving IBM, managing director.

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Figure 4 The FlyBy guideway proposal (yellow) and extensions (brown)

During our feasibility studies spring 2002 and later, we did a PRT concept study for the Fornebu – Lysaker area under the work name of "the FlyBy rail". The network outline is shown in Figure 4. Approximate extensions to cover political decisions and wishes summer 2002 are also shown (brown lines), but not yet included in our estimates.

To identify the specific properties of such a FlyBy PRT implementation, we have walked through many of the (often enthusiastic and optimistic) PRT studies available, and done conservative estimates and calculations for a system installation. In Figure 5 a summary of our findings are compared to equivalent information as to the APM elevated rail case study carried out for the local government project white books (Akershus fylkeskommune 2001 and 2002).

Although we have used leading traffic planner expertise and made use of (revised) calculation models from several system developers, we consider our findings to be non-conclusive, and due to be revised when the design is more detailed. Also, as there is no experience from factual operation, figures must be understood as best estimates at the time of writing. However, even with large margins, our analyses come out clearly favorable to the FlyBy PRT system over an APM system. Some very important topics depend on the specific implementation, and others on the will of public authorities. Hence, they are still open, as indicated in the table.

Extensive theoretical, concept, and empirical studies, as well as project studies for specific urbanisations have been carried out concerning societal costs and gains, technologies, safety, etc. The picture conveyed through these studies is fairly congruent to the above claims (e.g. Andréasson, Johanson & Tegnér 2002).

Yes, It Can Be Done – And Almost Is

A major finding of our feasibility study was that PRT now seems technologically feasible, despite historical evidence. But organisationally it seems still challenging:

More than a hundred automatic elevated rail systems for public transport are in operation around the world. None are PRT in the strict sense of the term defined above. The literature on PRT is extensive and the number of project studies for cities small and large around the world is impressive. Several systems have been built around various projects as test sites and are no more in operation: ARAMIS in Paris, Cabinentaxi in Hamburg, CSV in Japan, PRT2000 in Chicago. The Morgantown GRT, West Virginia, USA, however, built in 1971, has transported more than 25 million passengers and has 99 % uptime in a hilly and snowy town.

There is also a substantial literature analyzing why the various PRT initiatives so far have failed (e.g. Latour 1997, Rydell 2002, Burke 1979). Roughly, they identify the same set of reasons for failure that often follow trajectory disruptive new concepts: The launch of immature technology, the "Not invented here!" arrogance, unclear business models, strifes around ownership to ideas, compromises ruining critical features, resistance to a new mindset, etc.

Behind the failed projects one also finds detrimental political plays in government and the

Parameter	PRT compared to APM
Investments costs	Down approx 1/3.
Operations costs	Down approx 25 %
Capacity	Rush hour demand met by 1.5 sec headway and 3 passengers/vehicle.
Travel times	Mean travel time down 1/3 to 1/2
Wait times	No wait outside rush; max 1 minute during rush. With APM 1 to 5 min.
Energy consumption	1/5 to 1/6 of APM/"light rail".
Visual and sensory intrusion	Smaller, leaner, more silent, more spread out, but more frequent.
User attractiveness	Higher due to smoother transfer at Lysaker terminal.
Passenger requirements	Same or better level, but: room for weelchair, no standing, no skis.
Realism to meet timeframe (2006)	Clearly feasible, as APM.
Area coverage	Substantially better – Compare on maps.
Extensions	Easier, faster and cheaper build outs as long as traffic is fairly balanced.
Flexibility of investment	Higher – as stepwise build out is practical.
Mean overall travel speed	Fixed speed approx 40 km/h. For APM around 20 km/h, decreasing with length travelled.
Limitations caused by weather (wind, snow, ice, cold)	Solutions exist. Depend on implementation.
Mean time between failures (MTBF)	Depends on implementation. Still open.
Safety	Depends on implementation. Higher risk spread. Still open.
Safety regulations	High risk for PRT, as safety regulations for rail systems are designed with very different concepts in mind. Still open. For APM: no risk.
Overall vulnerability to operation stops	Depends on implementation. Still open.
Proximity to white book concept	PRT is closer to wished functionalities. Only APM is analyzed.

Figure 5 The FlyBy case – performance on relevant parameters

clumsiness of large corporations – with an organisational maze and culture killing off innovation. According to some (Rydell 2002) there are even proofs of direct – and illegal – obstruction from the part of incumbent transportation systems suppliers, mobilizing laws and regulations to be used against their intentions.

However, the preconditions for implementing PRT are now all changed: The concept of PRT has been refined. The political pressure to search for new and environmentally sustainable solutions to urban congestion is now of a different order of magnitude than only a few years back. Also, what can be done at affordable price with today's off-the-shelf technology was not imaginable just 10 years back. Hence, Martin Lowson, himself a developer of the ULTra PRT to be in operation by 2005 in Cardiff, can list quite a few PRT systems under development in his paper (Lowson 2002, this issue of *Telektronikk*).

In fact, there are implementations of transport systems very close to PRT already at hand: The baggage handling system at the Oslo airport (Gardermoen) – a world first of its kind and later duplicated at several airports – satisfies the above mentioned design criteria of a PRT system – apart from some criteria linked to handling people, not luggage!

After a series of consultations fall 2002 with relevant transport engineers to address particularly the problems of snow and ice, we have been able to identify solutions that seem to make even these problems fully managable as to rails,

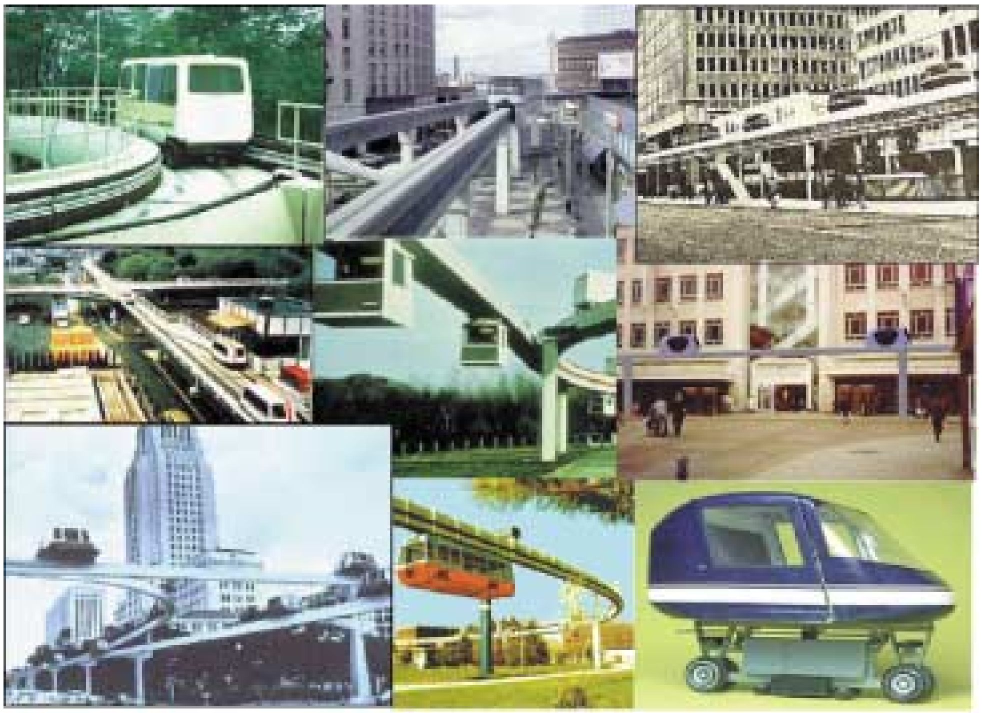

Figure 6 Some examples from the development towards today's PRT concept

switches, propulsion, steering systems and brakes – even without the use of heating or chemicals. The development of a full PRT system to be in operation by 2006 thus seems technologically fully feasible.

The remaining should thus be a question of commercial conditions, organisation, financing, and will.

The Business Case – PRT as an ITS Application

PRT caught our interest for several reasons:

One of them was the ease with which the FlyBy enterprise, once established, could be duplicated at other locations in Norway as well as abroad. Hence, development costs in the FlyBy case could be considered the entry ticket to a new business and new markets.

Another reason was the PRT idea as a business that really matters, as it addresses real problems that urgently need solutions. Yet another reason was that PRT, in the context of FlyBy, is a relatively low risk operation: The costs up until a tender can be handed in seem modest considered as an eventual major business development project.

But not least, PRT caught our interest because of its close relation to the core elements within Intelligent Transport Systems (ITS), a growth area within ICT. In PRT, the technical core elements are stuff like automation, "failure safe" fleet management software for optimation of dynamic systems in true time, sensors, positioning information (e.g. GPS), radio communication, lightweight, and safety overdesign.

These core elements are common to ITS, as they are to the ICT business. As shown in Berland 2002 (this issue of *Telektronikk*), central system design thinking within ICT – mobile computing and the Internet in particular – is easily and fruitfully transposed to PRT fleet management systems. The very same core elements and the dynamic system design thinking are however foreign both to the traditions of businesses of public transport and construction.

The core of PRT – ICT components for automation – are no longer unproven, nor expensive, nor bulky or heavy. On the contrary they are conventional ICT technology. Applying standard ICT elements on a new area where the market for years has been seeking solutions, means following the text book theory of entrepreneurialism: It still, but for a limited time only, offers first mover advantages for innovative enterprises.

But as always with innovations, there is a risk: The PRT business models are unclear, or at least different from traditional public transport. The patterns of investments, operations and modifications are different. Even the reliability criteria need to be different and will need standards and benchmarking to be well thought through: For example, how do you measure uptime in a mesh network based on best effort? The definition established for the traditional network is not applicable. It needs an overhaul not to create backwardish resistance – precisely as when the Internet met the established telco business with its "toyish" new and lean structures.

If PRT were conventional to the industry, there would be no risk, nor any first mover advantage, nor any trajectory disruptive change in the development of urban transport.

The FlyBy Consortium

The Telenor corporate management has so far only considered PRT to be of substantial value to the attractiveness of the Fornebu area and to society at large, not as a business idea for the corporation.

Accordingly, the Telenor initiative is limited to taking the lead in the establishment of a consortium that could qualify for the tender process with a PRT proposal. At the moment of writing, the consortium consists of just two partners, Telenor and Statkraft, the latter being a 100 % government owned incumbent hydroelectricity producer.

Statkraft is a shareholders' company with ambitions to become an important supplier of "green" electricity, whether produced from hydropower turbines, windmills, or hydrogen fuel cells. For Statkraft, the FlyBy project is a show case opportunity for "green" electricity supply, as well as an opportunity to contribute to moving public transport in the direction of "greener" transportation modes. Applying its methodology for environmental impact certification, we see that even public transport may get its product declarations as to environmental impact.

As of mid October 2002, talks with several PRT system suppliers have been going on for months. However, none have so far been chosen, as none were found to have solutions on the drawing board that could master the required combination of climate, PRT features and implementation schedule. By a major overhaul of our thinking around PRT, we believe now to have found the relevant technical solutions, and a list of relevant suppliers of all main elements has been established. Hence, more concrete plans, evaluations and estimates can be worked out.

The prequalification round scheduled to start by February 2003, will reveal essential elements of the PPP (public private partnership) terms. It is thus a natural milestone and eventually an exit point.

To continue after "beauty contest", the consortium must get more partners. Talks with candidate partnering companies have been going on for some time, but have so far not concluded. As uncertainty reduces step by step, the project will hopefully attract the financial partners necessary for the work to be carried on until handing in a tender fall 2003.

Conclusions

The ICT business has an opportunity – as well as a social obligation – to help introduce PRT, and thereby contribute to breaking the trend of public transport losing ground. By implication, it means that players foreign to public transport should seek to cooperate with the sector's incumbents, alternatively challenge them by entering their markets. As the demand is there already, and estimations indicate that PRT may give substantially better economy than the alternatives, the business models will come.

We have found that the impediments are no longer technological, nor connected to costs of investments or operations. They now depend on willingness to bring about change!

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