The integral assessment of PRT for Scienceport Holland

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Abstract

For a new science park in the cities Delft and Rotterdam a feasibility study has been made for a PRT system that would connect both parts of the science park with each other, with a local airport, and with the rail network. The opportunities for such a system are excellent, but a discrepancy exists between such a new transport system and existing plans.

PRT would strengthen the role of existing public transport, it would reduce car traffic inside the service area but it would not have a significant impact on car usage for trips to and from the area. The passengers would come from users from public transport, cyclists and car drivers who leave their car at a parking place and continue by PRT.

The challenge of the feasibility study was to find a stakeholder that is able, willing and strong to push the next step to implementation.

1. Introduction

In the region between the cities of Rotterdam and Delft a high technology area is planned with the name Scienceport Holland. It is composed of two areas, one area, called Technopolis, is connected to the campus of Delft University in the North and the second subarea, in the South, is called Schieveen and is close to Rotterdam/The Hague airport in the South. Both areas are close to the A13 motorway, which is characterized by a lot of congestion twice a day.

For Scienceport Holland research has been done to identify the feasibility of PRT with the objective to connect both subareas with each other and to make them accessible from existing public transport. The results were promising in terms of technical and economical feasibility.
The study area included two cities, Rotterdam and Delft. Delft is a part of the larger urban area Haaglanden, Rotterdam is the central city of Rotterdam Urban Area. The responsibility for public transport is carried by the urban areas. Next to the two Science Centers Technopolis and Schieveen, the PRT system would also serve the airport of Rotterdam and The Hague. This airport is located at the North of Rotterdam, close to Schieveen.
At present public transport at the locations of Scienceport Holland is given by busses that connect the area with the railways stations in Rotterdam and Delft. A new tram line is planned between Delft railway station and the campus of TUDelft and the new Technopolis area.
The approached followed in the study is similar to the one in some other studies, e.g. done in the framework of EDICT (2010). First of all the future demand was estimated using the national transport model and a modal split model. Section 2 contains some details about the results. Afterwards, a suitable network has been designed and the demand was assigned to the network. This was input to a simulation. The simulation was used to determine the optimum fleet size. The cost for the operator of the system was balanced with the costs of waiting time at the PRT stations. Section 3 explains this further.
The investment costs have been estimated using some data from existing PRT projects, especially the Heathrow system. With help of a simple calculation model the yearly costs for depreciation, interest, maintenance and operation are calculated together with the costs for the staff. This is reported in section 4. The system has some financial profit in terms of incomes from fees, the increase of value of real estate around the PRT stations and the possibility to realize a higher density of buildings because fewer parking spaces are needed. Section 5 gives more details. Finally the institutional and political aspects are discussed in section 6. A plan for an innovative transport system interferes with existing public transport plans, is sensitive to the changes in spatial development and has to compete for funding with other plans. Section 7 gives more information about these issues.

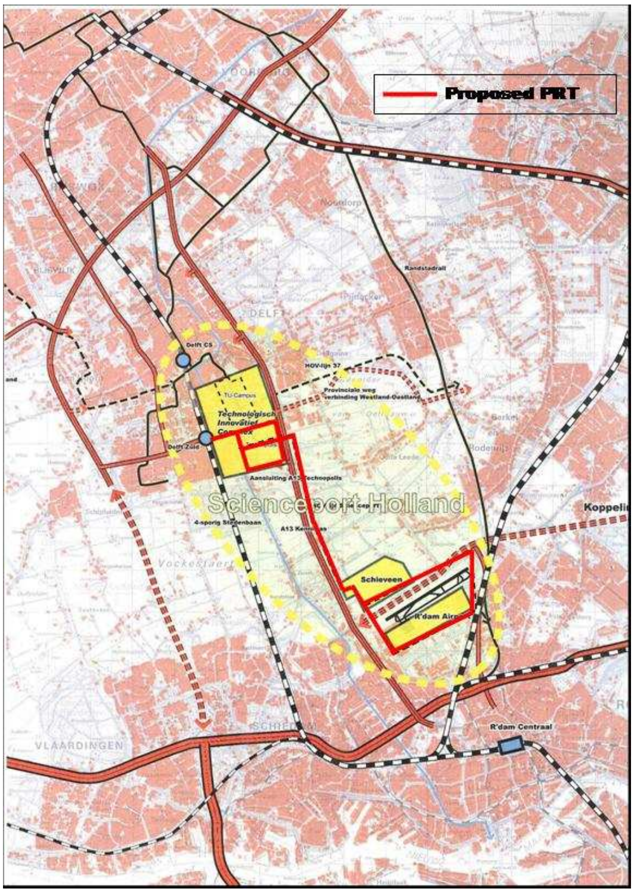

Figure 1 The area for which the feasibility of PRT has been investigated

2. The demand estimation

The demand for transport was estimated based on the number of labour places in different parts of Scienceport Holland. This demand was spatially allocated to origins and destination in the Netherlands. For the spatial allocation the transport demand model of The Netherlands was used (Omnitrans 2010) and for the modal allocation a model was used that has been developed for a similar situation: modal choice at the campus of the Technical University in Eindhoven (Minderhoud and van Zuylen 2002). The model contains the weight given to different aspects of PRT and other transport modes, like out-of-pocket costs, waiting time, in vehicle time, access time. This was done for short and longer trips and for different weather conditions.
The model used was a utility based logit function

$$S_j = \frac{\exp U_j}{\sum_{j' \in J} \exp U_{j'}} \tag{1}$$

Where S_j is the fraction of trips that will be made with mode j, and U_j is the utility of mode j, expressed as a linear function of attributes as enumerated in Table 1.

$$U_j = \sum_i p_{i,j} X_{i,j} \quad (2)$$

p are the weights for the different attributes, X are the values of the attributes. Table 2 gives the weights p for PRT.

Table 1 Attributes of a PRT trip

Symbol	meaning
Walk	Walking time (min)
Wait	Maximum waiting time (min)
Driver	0 = with driver, 1 = automatic
Comfort	0 = tram/bus, 1 - luxury car
Share	0= share, 1= non-sharing
Time	Journey time (min)
One-way fare	Fare in euro

Table 2 Sensitivities for different aspects of a PRT trip

Attribute	sensitivity
Walk	-0.1429
Wait	-0.236
Driver	-0.299
Comfort	-0.0687
Share	0.3121
Time	-0.02359
One-way fare	-0.86

With this logit model the share of PRT could be determined (Table 3 and Figure 2).

Table 3 Shift in modal choice after introduction of PRT.

	Situation without PRT	Situation with PRT	difference
Car trips inside Scienceport Holland	25.300 trips	18.600 trips	-27%
All car trips	25.300	25.300	marginal
Bicycle	6.700	3.900	-42%
Public transport	10.600	12.200	+15%
Public transport combined with PRT	0	7.200	
PRT only	0	2.200	

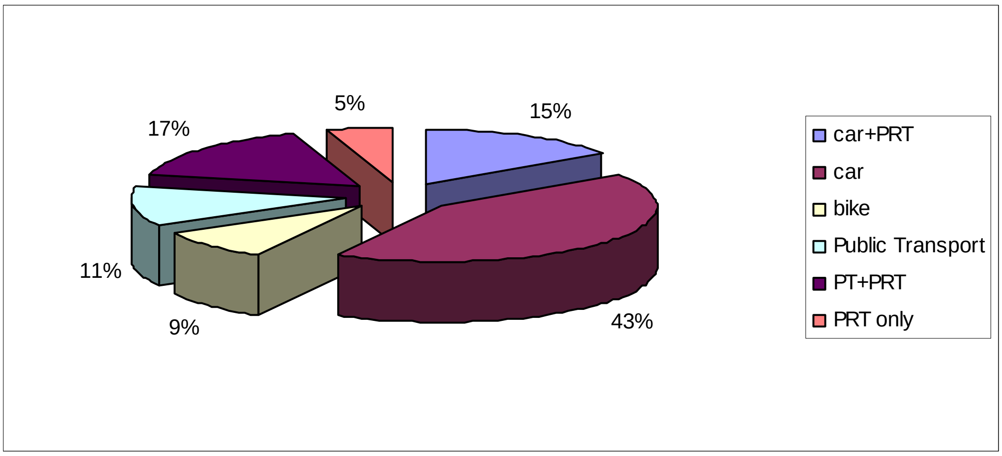

Figure 2 Modal share for PRT

A further conclusion from the demand analysis was that most expected demand was related to the area close to Delft University of Technology. Furthermore, the airport would generate demand especially towards a station of the railways close to the terminal building. The findings from the survey done for the Eindhoven campus shows that about 30% of the car drivers would prefer to park their car at a transferium and travel by PRT to their final destination.

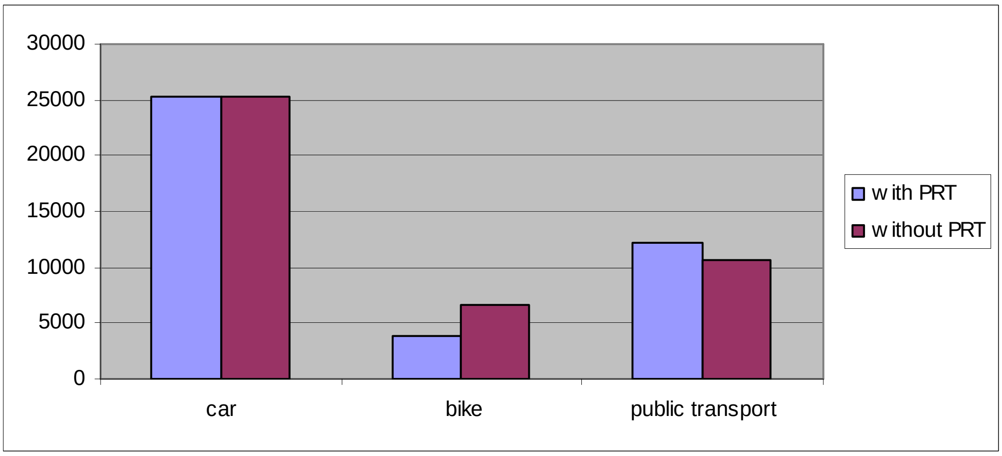

Figure 3 Modal share of car, bike and public transport in trips per 24 hours in the situation with and without PRT.

3. Simulation and optimization of fleet size

The demand for PRT was used to set up a simulation and to identify the optimum number of vehicles. This was done by optimizing the costs for travelers in terms of waiting time and the costs for the PRT operator. The simulation model used the spatial demand pattern as derived from the travel demand and modal split model, as described in section 2. The simulation of the operation of the PRT system contained a rerouting algorithm for empty vehicles as developed by

Andréasson (2003). This algorithm was integrated in the simulation program PRTsim developed by Andréasson (2009) that we used in the case study.

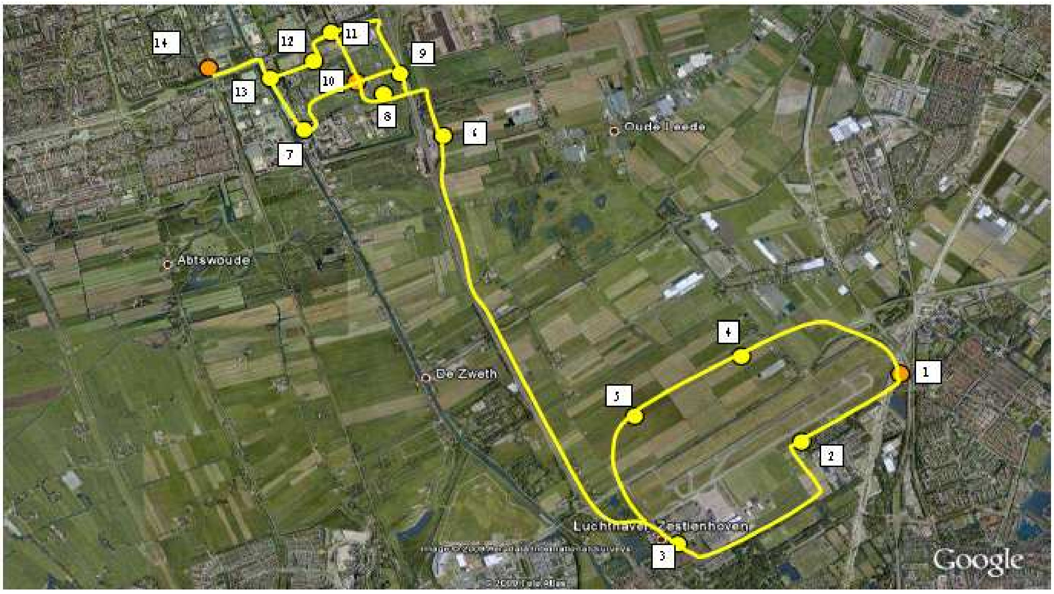

Figure 4 Scheme of the full PRT network for Scienceport Holland

The costs of the operation and use of the system consist of the user’s costs and the operator’s costs. The user’s costs are the travel fare, which is independent of the fleet size, the travel time cost and the waiting time cost. Only the last cost depends on the fleet size. This was determined by the simulation.
The operator’s costs were composed of the running and maintenance costs of the vehicles and the depreciation and interest on the investment. It is obvious that the operator’s cost components are all linear proportional to the fleet size. Figure 5 shows the result with the total costs for the user and operator. An optimum could be obtained at a fleet size of 70 vehicles.
The calculation assumes that the demand for PRT would not change with fleet size. In reality one may expect that a smaller fleet size will give a longer waiting time and thus a less attractive PRT system. That will reduce the number of passengers; with the consequence that the incomes for the operator will be less on the one hand side and that the waiting time will be experienced by less passengers. The elasticity of the demand with respect to waiting time can directly be derived from the modal split model as described in section 2. In the most extreme case – no vehicles – the costs for the operator would be zero and no traveler would use the system, giving no user costs. But in the surrounding of a more realistic number of vehicles the effect of the elasticity in demand on the final optimal fleet size is small and can be ignored in the calculation.

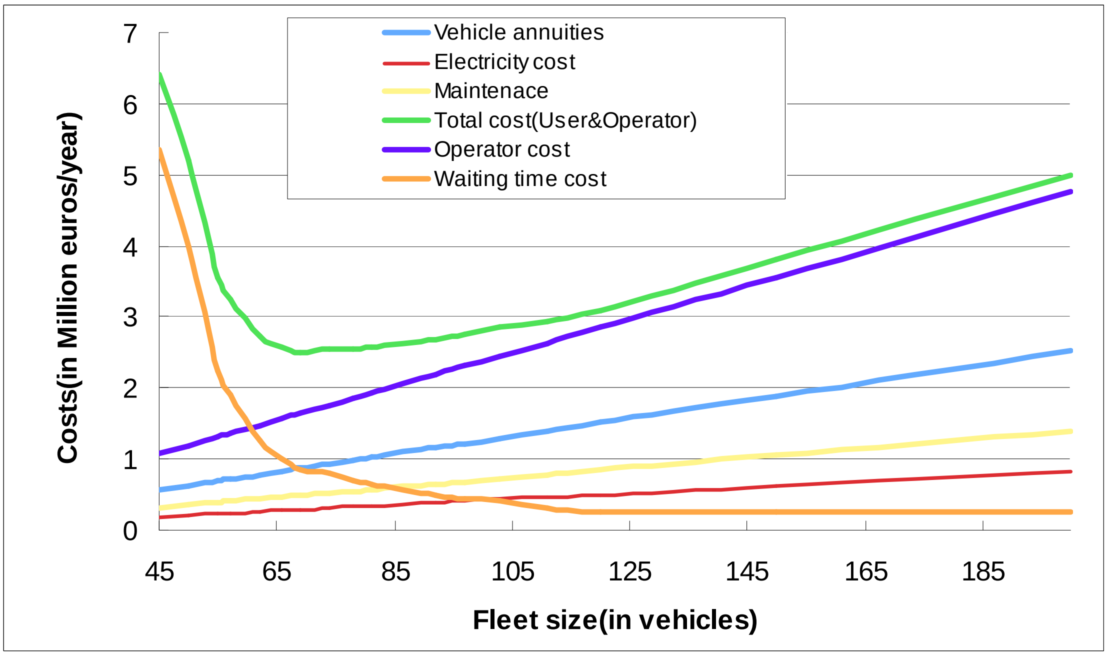

Figure 5 Costs as a function of the fleet size

4. Investment and operation costs

The total investment cost for PRT was estimated to be 110 million Euros. Next to the 70 vehicles, the track of 21 km and 14 stations have to be built. The following unit costs are used in the estimation:

Vehicle	€ 136,000
Station ground level	€ 400,000
Elevated single track	€ 5,200,000 / km
At grade track	€ 1,300,000 / km

For the estimate of the operation costs we have assumed that for the daily work permanent supervision is needed of 2 persons (4 shifts), that on the biggest stations during the busy times a ward should be present (2 shifts). Maintenance for the vehicles, tracks, stations, and electronics could be done during daytimes in 2 shifts. The same applies to the cleaning of the vehicles.

The costs for the operation, including interest on and depreciation of the investments, maintenance etc. is 5.5 to 8.7 M€. The lower amount is for the case that 50% of the investment costs are subsidized, the higher applies to an unsubsidized situation.

The costs for electricity will vary in the future; now we assume 0.22 €/kWh (in 2009 the consumer price was about 0.15 €/kWh). We could consider providing a part of the track with solar panels in order to reduce the energy costs. Assuming investment costs of € 700 for a panel of 1 * 1.5 m^2 and an average energy of 200 kWh/year and 30% of the track to be suited for solar panels, we could get 1400 MWh/year out of solar energy for an investment cost of about 5 M€, an increase of track investment costs of 3%.

Part of the costs could be seen as investment in the better accessibility of the area. The costs for operation of the PRT system would be 9 million Euros, if no subsidies would be available for the investments.

Figure 6 An artist impression of PRT at the terminal building of Rotterdam/The Hague airport.

5. Benefits

First of all the benefit will be that a high quality transport mode will be available in an area that should have the characteristics of a Science Park. The quality of transport with high speeds and short or no waiting time will improve the characteristics of the area. Furthermore, two sub areas that are now badly connected (just by a motorway that has serious congestion during the peak hours and even in the weekend) will get a smooth and fast connection with each other. The airport will be virtually integrated in the Science Park. The connection with other (rail based) public transport will be realized.

The attractivity of the Science Park will make it possible to make more money for the real estate in the area. Debrezio et al (2006) and De Graaf et al. (2009) analyzed the value of office buildings around stations of high quality public transport. They found that this value is about 15% higher then similar buildings on larger distance from the stations. A rough estimate of the building’s value in Schieveen gives a value of 432 M€ while in Technopolis the value is about

540 M€. Together this leads to an increase of value with 146 M€, even more then the necessary investment budget.
The operation of PRT will create incomes from the fares. Given the daily number of trips of 16,000 and a fare of 1 € average will give 3.7 M€ incomes per year. Compared with the operation cost of 5.5 to 8.7 M€, the costs are covered for at least 43 %. This is similar to the average situation of busses and trams, where the government gives 60% subsidy.

6. Institutional context

As described in the introduction, different institutions are involved in a possible implementation of PRT. The municipalities of Rotterdam and Delft are directly responsible for building permissions and spatial planning. The Urban Regions Haaglanden and Rotterdam are responsible for public transport. The central government would play a role in the investments since a part of the budget might come from innovation funds.
The private institutes are

- Delft University of Technology,
- Airport Rotterdam / The Hague,
- RET, the tram company in Rotterdam,
- HTM, the tram company in The Hague,
- Dutch railways.

Of course, also institutes that have a building in the Scienceport Holland area have a stake in the possible new transport system. As will be made clear in the next section, the most important player should be Delft University of Technology, because the university, as owner of Technopolis and the campus, has most profit from such a new transport system.

7. Conflicts with spatial development and other plans

The first conflict that appeared came from the postponement of the development of the Southern part of Scienceport Holland, Schieveen. There is an excess of office space in Rotterdam (as in most cities in Europe and USA). Due to the economic crisis the demand for office buildings is low and the development of a new area would not be justifiable in social and economic terms. That is the reason why Schieveen will not be developed in the next 10 years.
The other conflict at the side of Rotterdam is the plans with the airport. Since the airport is very close to residential areas, noise is a serious problem. Rotterdam does not want to stimulate a further growth of the airport. If a new, advance transportation system would be built, it would give a signal to the outside world that might lead to misunderstanding. Rotterdam municipality preferred to have a simple bus shuttle between the terminal building and the nearby railway station.
At the side of Haaglanden the situation is slightly complicated due to the plans for a new tramline between Delft Central Station and the campus of Delft University of Technology. The tramline would be exploited by HTM. It was agreed already many years ago, the budget was allocated and a part of the track has been made ready for implementation. However, a bridge along the track appeared to have

some weaknesses and will not be ably to carry the tram. The improvement of the bridge takes several years, so that the new tramline can not be built yet.
Delft University of Technology is unhappy with this delay. Furthermore, they fear that the tram will create electro magnetic fields that might interfere with sensitive instruments in some laboratories of the Department of Physics. A negotiation about possible use of ultra modern trams that do not give such strong electromagnetic radiation has not led to a satisfactory solution yet. Combined with the delay of the construction of the tram track, the opportunities for an alternative transport solution look well. The fact that the tram line has been approved already and the budget has been allocated, make it extremely difficult to change the plans.
Of course, it would be rather easy to extend the PRT network to Delft Central Station at costs that would e lower that a full construction of a tram line, but part of the infrastructure is already prepared for the tramline.
A final, more positive, interaction with existing plans and regulations is that fact that PRT could reduce the demand for central parking places close to the buildings with working places. About 30% of the drivers appear to be willing to park their car outside the central area and use PRT for the last part of their journey to work. Delft municipality imposes standards for the number of parking places for new buildings. A representative of Delft municipality was willing to talk about adaptation of these standards if PRT would connect the working places with a parking place outside the central area.

8. Conclusion

The original plan, to connect both parts of Scienceport Holland, has to be abandoned. Schieveen will not be developed and the airport has not sufficient demand to justify an investment in a PRT system. Since that part of the study area generated only 30% of the total travel demand, it would be economical feasible to have the much smaller PRT system in the Northern part of Scienceport Holland, Technopolis. Several options exist to enhance this small network by serving also a part of the campus and possibly act as a replacement of the planned tramline between Delft University of Technology and Delft Central Station.

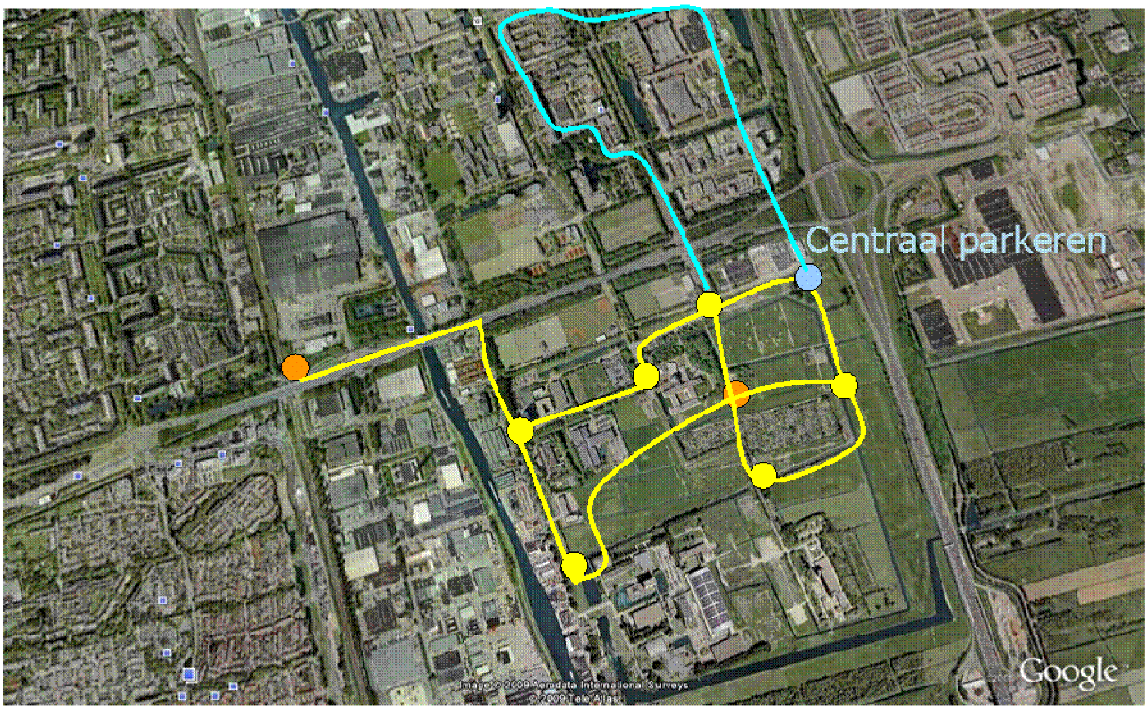

Figure 7 The reduced PRT network for Technopolis with an extension to the campus of Delft University of Technology to serve as link with a possible new central parking building. The connection with the planned tram line is still present (orange dot in the middle). The orange dot left is the link with the small railway station Delft South.

Most important from the study is the conclusion that it will be Delft University of Technology who has most interest in a PRT system and who will enjoy most of it benefits. It is obvious that after the completion of the feasibility study, the next phase has to be initiated and pushed by the university.

9. Acknowledgements

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