Implementing new transport solutions in existing transport models

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***Abstract*—This paper looks at implementation of new transport solutions in existing transport models. PRT and CyberCar solutions are tested on specific transport problems in Trondheim. Implementation of new solutions, results and lessons learnt from the implementation phase are presented.**

Keywords-New transport solutions, PRT, CyberCar, transport models

I. INTRODUCTION

Urban planners are faced with an increased focus on the negative impacts from movement of humans and freight. For Norway there seems to be a trend that growth in GDP and private consumption is linked to the growth in the use of transport(Samferdselsdepartementet, 2008). But having a good transportation system is vital for maintaining the present standard of living. This means that we are faced with a challenge to allow for growth in the transport sector while reducing the environmental impacts.

Add-on technologies to the petrol engines such as catalytic converters, cleaner fuels and more efficient vehicles can greatly reduce the level of pollution. For diesel engines there can also be improvements but on a smaller scale. But when the reductions are compared to the increase in car ownership it is not apparent that this will help us out of the squeeze. At best catalytic converters will give us a 10 year period before pollution levels start to rise again. For CO_2 emissions there is not found a clear trend that shows an increased efficiency in the vehicle stock(Banister, 2005).

This gives rise to the question can "new transport solutions" give us a more sustainable way of organizing urban transportation. If we think this is the case then the next question is where is: Where is the best place for implementing these new solutions and at what scale? It can be tempting for a planner to look to transport models for answers. This paper will look at the new transport solutions, explore their attributes and do test implementations in existing models, present results and account for lessons learnt in the implementation phase.

II. THE NEW TRANSPORT SOLUTIONS

"New" transport solutions can be quite misleading. Alternatives to the car, bus and rail have existed for quite some time. But the alternatives have never achieved mainstream popularity. "New" does not seem to be describing the novelty of the technology, but rather the fact that there are very few implementations of these transport solutions. But there is a wealth of systems under development. Jerry B. Schneider maintains a list: "Comparison Matrix of Ready and Emerging Innovative Transportation Technologies"[1] that currently holds just over 100 new solutions(Schneider, 2008).

One core concept of the new solutions is individualization of public transport. The idea is to treat the traveler as an individual, not as a group of individuals with fairly similar travel patterns. Hence new transport solutions should resemble the car. The service will not run as a scheduled service, but as an on demand service. The traveler will to some extent have the same control over departure time as with the car. Traditional public transport has a predefined route, schedule and a set number of stops to let people get on and off. The new more individualized transport solutions will be point-to-point, not stopping until you reach your destination.

[1] http://faculty.washington.edu/jbs/itrans/techtable.htm

Point-to-point public transportation is clearly different from a traditional bus route and should reduce travel time considerably. The hope is that this can contribute to a reduction in car usage.

This paper will look at two new transport solutions, one that operates in point-to-point mode (PRT). The other transport solution will operate in conjunction with and existing bus system (CyberCar).

A. ***PRT (Personal Rapid Transit)***

PRT (Personal Rapid Transit) is far from a new idea. The first time this type of transport system was described was in 1953 by Donn Ficter. He envisioned a transportation system for the city which he called Veyar. In 1972 the US launched a federal PRT development program starting with some famous words from president Nixon: “If we can send three men to the moon 200,000 miles away, we should be able to move 200,000 people to work three miles away. “(Anderson, 1996) But so far very few PRT systems exist. One system that is frequently referred to is the Morgantown PRT[2]. The Morgantown PRT started operation in 1975. The system was to connect the different parts of the West Virginia University Campus.

At present several companies are looking into building PRT systems. Vectus ltd, UniModal Inc, Mister ltd and Advanced Transport Systems ltd are a few companies that are actively promoting their PRT systems through the usage of demonstrators. Advanced Transport Systems is currently building a PRT system at London Heathrow international Airport.

PRT can be on demand systems that brings the traveler directly from A to B. The carrying capacity of each unit is usually around 1 to 4 persons. The small units run automatically without a driver on a network of guide ways. The whole system is controlled by a central control system that distributes units according to demand. All stations are offline, thus letting units that should not stop pass by unhindered.

The reason for a carrying capacity of more than one is to let small parties travel together if they both share the same origin and destination. This will also increase the capacity of the system. If one removes the same origin and destination criteria then you get at GRT system (Group Rapid Transit). The earlier mentioned Morgantown system resembles a GRT system. Several users can enter the unit and chose their destination. When the unit stops, passengers may get off and others may get on. The Morgantown system can also function as a bus if wanted, stopping on each station letting people get on and off. The Morgan town PRT vehicle has capacity of 20 users.

One challenge for strategic evaluation of PRT systems is the flexibility these systems offer. The mode of operation can change from point-to-point to line-haul with the flick of a switch. Capacity of a system is a function of unit size, but increasing unit size will move PRT systems closer to GRT systems which resemble more traditional public transport. If one moves away from the more individualized mode to a more group oriented mode of operation one can influence the perceived attractiveness of these systems thus influencing the demand. This means that planners not only have to look at the physical layout of the system but also the systems mode of operation.

B. ***CyberCar***

The CyberCar is a fully automated road vehicle. The CyberCar is physically more like the car in a sense that it follows one of the oldest standards around, the paved road. The vehicles can operate to serve a simple line or run in a network configuration. The cars can have varying systems for obstacle detection and avoidance. Radar, laser and video can be used for these tasks. The same is true for navigation, where several different methods can be used(Parent, 2007).

The capacity of the CyberCar can vary. The Parkshuttle II operating one line in Rivium in the Netherlands has a capacity of 20 persons[3]. The prototypes of CyberCars used for the CityMobil[4] showcase in Daventry had a capacity of 2 persons. In the case of a feeder system a unit with few seats will be more individualized. While if a CyberCar with 20 passengers is used you will be affected by others getting on. Thus you will not be taken directly from A to B. Operation of the larger vehicles will resemble the workings of an elevator, rather than point-to-point.

At present operating CyberCar systems are running on segregated tracks. This is partly due to the navigation systems that are in use. The Parkshuttle uses dead-reckoning with re-localization by magnets for navigation.(Parent, 2007) This means that the vehicle follows a static route. Another barrier to running the

[2] http://en.wikipedia.org/wiki/Morgantown_Personal_Rapid_Transit

[3] http://connectedcities.eu/showcases/parkshuttle.html

[4] http://www.citymobil-project.eu/

CyberCar on a normal road is linked to legal issues. At present laws are based around a concept of a human driver that is in control and responsible for the vehicle (Ragnhild Wahl et al., 2007). A CyberCar will only have passengers and no drivers. In a full network configuration CyberCars will interact with cars, pedestrians and other obstacles. These technical issues can also be barriers to implementing a CyberCar system that operate on normal roads.

If a system is built around the Parkshuttle model then signalized crossings will be put in place to hinder other cars from coming in direct conflict with the CyberCars. In an urban scenario this will lead to heavy regulation of existing traffic in areas not fully signalized. Areas where roundabouts and right-of-way are used for regulation will clearly be affected. This can result in reduced driving speeds for car going through these areas after CyberCars have been introduced.

C. A land of shades

The brief introduction above hopefully shed some light on the possibilities of the new transport solutions. But also gave an indication that there are numerous shades of these technologies. The physical and technical layout is one side, mode of operation is another. PRT can take any shade from fully individualized point-to-point transport to operating just like a bus on separate infrastructure. CyberCars have the same possibilities but can also function without dedicated infrastructure given that legal issues do not stop this mode of operation.

For a strategic planning it is important to be able to navigate this land of shades since PRT and CyberCar mode of operation can influence perception and performance. Some attributes of PRT and CyberCar systems are not binary, but multi level. This is the case when it comes to the degree of individualization. A car is under full control of the driver. The driver can choose the sequence of stops, number of passengers and to use the same vehicle for the whole journey. A PRT system can function in the same way, but then one can start to remove individualization traits. E.g. the system can be setup so that when you leave the unit it becomes available for other system users. To increase capacity one can allow more users in a unit if they are going to the same destination etc.

To get a clearer view of the challenges of making strategic assessments about new transport solutions two problem areas in Trondheim were identified where new transport solutions could be of help.

III. APPLICATION OF THE NEW TRANSPORT SOLUTIONS

After finding two transport problems the new solutions were studied to find how they best could solve the problems at hand..

A. Possible implementation to specific problems

The city of Trondheim is fairly small city in European terms with approximately 150 000 inhabitants.

One transportation challenge in Trondheim is linking the university campuses, hospital, city-center and the residential area to the west together. Here a PRT like solutions was thaught to be the most suitable. The system was to run in point-to-point mode with 32 stops. The stops are placed so that walking distance should be less than 500 meters for attractive destinations at the university, hospital and city centre. The system should have small unites with a capacity of 2 persons and run on demand. Commercial speed of the system should be 40 km/h. The system follows the existing road network but is elevated. Figure 1 shows the PRT system for Trondheim.

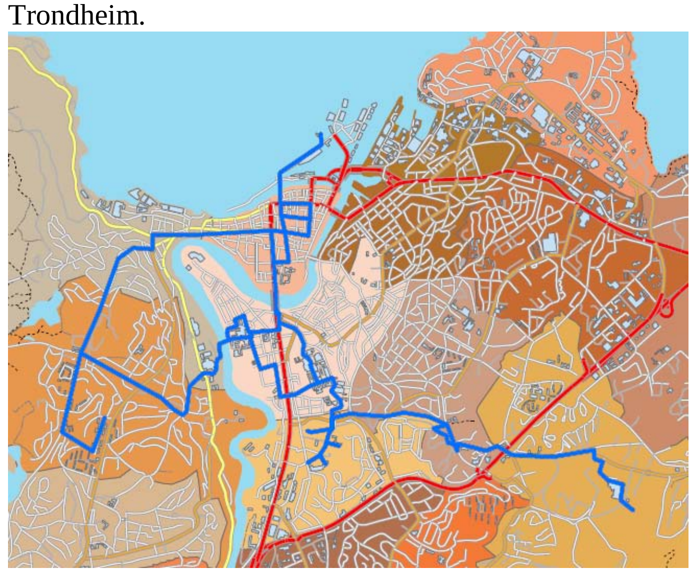

Figure 1 PRT system for Trondheim (blue line)

The other problem is public transport coverage. Trondheim has residential areas that are quite scattered, which makes it hard to get good bus coverage while keeping bus travel time down. A CyberCar feeder system for the bus was chosen for this task. The idea is that passengers order a CyberCar for a specific bus. The CyberCar picks up the passenger and brings him/her to the bus just before it leaves. To make the system as attractive as possible small units are used. Small units will ensure a very individualized mode of operation. Existing bus routes 20 and 60 will be “straightened” thus reducing travel time for whole route. An estimated 5 minutes would be gained by reducing the route length and removal of 4 stops. Figure 2 shows line 20 and 60 before introduction of the CyberCar feeder system (green and purple lines). Figure 3 show how route 20 and 60 have been "straightened" with the introduction of a CyberCar feeder system.

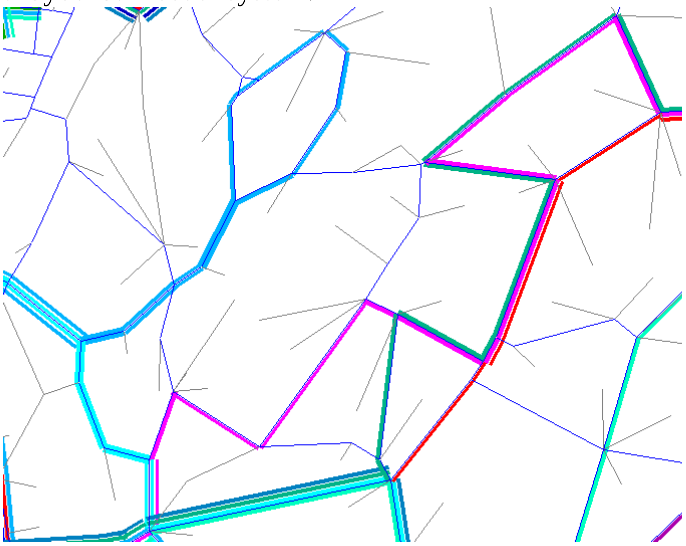

Figure 2 Bus route 20 and 60 before CyberCar system

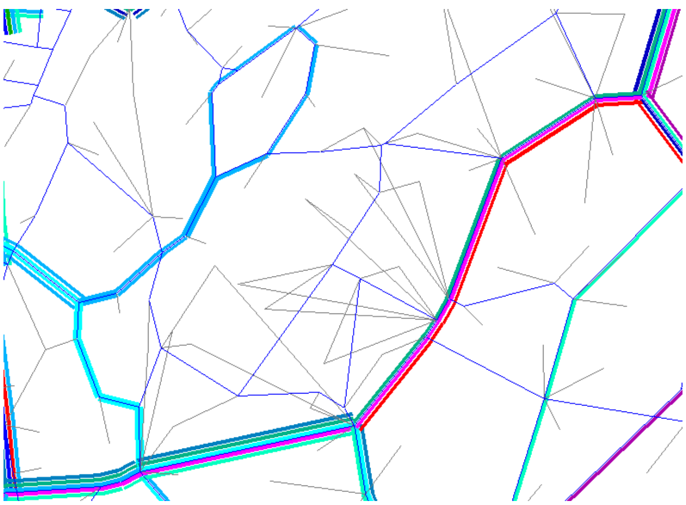

Figure 3 Bus routes 20 and 60 with CyberCar system

IV. MODELLNG THE NEW SOLUTIONS

Trondheim has a transport model for strategic transport studies that has been continuously developed since the early 90's. This model is classical 4-stage transport model called TASS5. The other model is an integrated land use and transport model called MARS (Metropolitan Activity Relocation Simulator)[5] established for Trondheim by the CityMobil project. In CityMobil the MARS model will be used for modeling studies of new technologies. For this test implementation an early version of the MARS model for Trondheim was used. Common for both models is that the models framework was not created with new transport solution in mind.

The MARS model uses more input data, but at a higher level of aggregation then the TASS5 model. Data used by both models were taken from the same sources. Land use data like developable area, average rent and average space per business location are examples of the more detailed data only being used by the MARS model. The MARS model is presented in detail in (Pfaffenbichler, 2003). (Pfaffenbichler et al., 2008) present results from testing the MARS model against other LUTI (Land Use and Transport Interaction). The results show that the MARS model is capable of producing results adequate for strategic decisions.

One specific feature with the MARS model is the missing the assignment phase. This has two notable impacts that users should be aware of. First the lack of an assignment phase means that users can not use the model to look at route choice problems. The model can give answers to problems at corridor or area level. The other problem is that initial distance and cost matrices must be estimated with other tools as the MARS does not have a network representation of the transport system. The advantage of not having an assignment stage is reduced runtime. A typical MARS run is less than a minute. The TASS5 model takes about an hour to run.

The zones in the MARS model consist of aggregate zones from the TASS5 model. MARS has 24 zones while TASS5 has 457 zones covering the same area. The TASS5 model has a network description of the transport system. Car, PT and slow are coded as separate networks. (Meland et al., 2006) gives a description of the TASS5 model with calibration and validation results.

The MARS model was chosen for this study because a large EU project CityMobil wanted to develop analysis tools to assess long term transport and land-use implications of innovative transport technologies, the MARS model is part of this toolset. The TASS5 model was chosen because it has been the "official tool" for strategic transport studies in Trondheim.

[5] http://www.ivv.tuwien.ac.at/forschung/mars-metropolitan-activity-relocation-simulator.html

A. Atributes of the PRT and CyberCar systems for Trondheim

The two transport problems briefly described earlier were chosen as case studies. The first stage was to look at the attributes of the new systems and how these could be mapped to existing attributes already used by the models. The idea was to find some generic way of implementing the new transport solutions. One of the major advantages of the new transport solutions is the inherent flexibility. Mode of operation, amenities and privacy/security features can vary greatly to fit specific cases. All the different variations within each of the three groups make it hard to create one generic PRT or CyberCar system.

Table 1 shows a summary of attributes for the two systems used for testing in Trondheim. The table is split into three sections: mode of operation, amenities and privacy/security. The mode of operation attributes has direct influence on travel time, capacity and degree of individualization. The group amenities hold extras that can be useful to certain users while not as useful to others. Navigation is one such attribute. Unfamiliar travelers might find navigation services to be of help. For commuters navigation might be of lesser value. The same is true for Wi-Fi. Only users that are in possession of equipment that utilize Wi-Fi will be able to take advantage of it. The last group focuses on privacy and security issues. In 2003 Robosoft[6] conducted an experiment in Bayonne France. 751 passengers took a ride in the RobuCAB, of these 238 filled out a questionnaire. More than 50% felt very secure during operation, but only 6% felt secure inside the vehicle from the outside environment(ROBOSOFT S.A, 2005). This could indicate that safety/security might be perceived differently from ordinary transport modes. Operation of the unit was seen as safe but the outside environment was threatening.

Attribute	CC	PRT	CAR	PT
Mode of operation				
Point-to-point	(x)	x	x	
Line-haul				x
Centralized control	x	x		
On demand	(x)	x	x	
Large scale relocation	x	x		
Amenities				
Navigation	x	x		
Online Wi-Fi	(x)	x		
Privacy / security				
Private space			x	
Control over fellow passengers	(x)	(x)	x	
Surveillance	x	x		(x)

Table 1 Selected attributes of new transport systems

[6] http://www.robosoft.fr

1) Mode of operation

The CyberCar (CC) and PRT systems for Trondheim will both function in a point-to-point mode. The CyberCar is part of normal bus service so it is only direct between the home and the bus stop, hence the parenthesis. Another common feature is that both systems are under constant control of a central system. This enables the system to optimize route choice and predict demand to ensure optimal performance.

The CyberCar feeder system it will not function fully on demand when it comes to time of departure. The idea is that departure time is calculated so that the CyberCar arrives just before the bus leaves. After ordering a CyberCar the user is informed of when he/she will be picked up.

Large scale relocation is the process of relocating units according to demand. This process involves moving empty units around. Approximately 30% of the units will be running empty at any time. This can have effects on the total capacity of the system. But different central management strategies can reduce this capacity reduction. One example is closer spacing of empty units.(Andréasson, 1994)

A PRT system fleet size can be reduced to half its size if occupancy increases from 1.5 to 3.1 according to (Andréasson, 2007). The PRT system in Trondheim will operate between points that will have large volumes going to the same places. To reduce the number of units needed the system should operate in shared mode between these two points. Only users going to the same destination can share the unit. This causes the Trondheim system to have two slightly different modes of operation on the same system. The same is true for the CyberCar system. A scheduled link is to be established between the bus stop and points with high demand such as large businesses that have lost the local bus stop. The idea of the split mode of operation is to reduce costs by reducing the number of needed units. This clearly shows how the PRT and CyberCar systems can have different shades to solve sub problems. It is no longer one system but a set of sub systems.

2) Ammenities

Navigation is one extra service that the new solutions provide. The system can either take you to the destination or give directions from the stop to your destination. The CyberCar system can take you directly to place you want to go. While the PRT system can give you directions from the stop to your destination. The new hospital under construction in Trondheim is build after a center model. There is not one large hospital building, but several small building scattered over the hospital grounds. The finished hospital will have more than 16 different public entrances. Navigation could be of great help to find the correct entrance for patients or visitors.

Wi-Fi integration can give users the possibility to "log on" during transport. This is possible since the user is not driving and free to do other tasks. CyberCars are put in parenthesis since the in vehicle time for the Trondheim case would be very short, about 2 minutes. This limits the usefulness of being online.

3) Privacy / security

None of the systems envisioned for Trondheim where to have privately owned units or units that can stay under user control while not being used. The possibility to have control over the unit while it is not in use can make it more like the car. In the Trondheim system you will not be able to leave your belongings in the unit if you make stops to go shopping or the like.

During the Podcar conference in Uppsala 2006 questions about protection from other passengers where asked. There seemed to be a perceived difference if the unit was operated by a person or that you were "alone" with the other passengers. For the person asking the question the bus driver held the role of a guardian. The representative from 2Getthere, the creator of the running cybercar system in Rivium, was asked about security. His view was that the amount of surveillance used could not stop an attack on a user. But it would give police an unrivaled documentation of the incident. In his view this could deter possible assailants. In the case of Trondheim the units will be operated on the basis of one unit one user. Security issues can then be reduced, but this has severe implications on capacity. More units or parallel lines will be needed if there is a reduction in occupancy.

The last attribute is surveillance. Developers presenting their new solutions have been talking about camera surveillance inside the unit, on stations and along the route to maintain a secure environment and stop vandalism. Personal identification will be used to validate legit users and hinder users from entering other users units. This can pose challenges to protection of the private sphere. Users and individuals in the vicinity of the stations or track can object to this type of surveillance. On the other hand some may perceive surveillance as positive for their safety and security.

B. *Modelling attributes*

It is not straight forward to model the attributes. Attributes in the amenities and privacy/security sections do not have equivalent parameters in the two models. For existing transport models issues of amenities and privacy/security have not been under scrutiny. It may be that these attributes are not perceived to influence the user's choice. Thus planners have to look outside the models to find answers to questions like: should the units offer navigation or Wi-Fi and will it affect usage?

Attributes relating to system performance like time and cost are fundamental in the transport models. Thus attributes concerning mode of operation should be possible to include in TASS5 and MARS model.

Implementation of the new solutions in the MARS model was done by ITS Leeds as a part of the CityMobil project. The modeling phase of CityMobil is not to be finished until later this year so all results presented here are preliminary and from an early model.

1) PRT in the MARS model

MARS does not have a network description from which travel time, distance or speed can be calculated. For the existing modes values were taken from the TASS5 model. Finding the travel time between the zones for PRT became part GIS work and part guesswork. The challenge was to find a placement of the zone centroid that would express the average PRT travel distance within the zone. An educated guess based on residential density and size of attractive origins and destinations was used to place the centroid. The GIS system was used to calculate the distance between all PRT zone centroids along a coded PRT network. Figure 1 shows the PRT network used. Walk time to the station was set to 2 minutes. PRT was said to have the same attractiveness as a rail. Headway was set to 1 minute to mimic on demand operation. The new PRT system was said run on an elevated track. It was presumed that the existing road space for car traffic was unaffected by implementation of the PRT system.

2) CyberCar in the MARS model

The CyberCar system in Trondheim is a feeder system for the bus. The model does not have a notation of a feeder system. A CyberCar feeder system will impact the access time to bus stop and the length of the bus route. In the MARS model the CyberCar system would reduce access time to the bus system. A spreadsheet was created to calculate a new equivalent walking time to be used as input for the model. Changes to in vehicle time due to line straightening are not taken into consideration. The effect a CyberCar system can have on other car users due to changes in road regulation is not modeled.

3) PRT in TASS5 model

The TASS5 was estimated without rail as a separate mode since there are so few rail trips within the city limits. Rail and bus are considered as one common PT mode. The PRT system was implemented as such a PT mode. The TASS5 model uses a network description of public transport services. To ensure point to point operations of services a complete set of express routes had to be created. With n number of stops one gets n^2-n routes. For the Trondheim case 1190 PRT routes had to be created. Doing this in a manual way would be very time consuming. The portion of the public transport network used by PRT was extracted for preprocessing. A Python[7] script was created to build a graph of the PRT network and to generate shortest path route descriptions based on Dijkstra algorithm for all pairs of stops. The script also produced the time table for the system based on 40km/h constant speed. Headway was set to 1 minute to imitate an on demand service.

No changes were made to the car network since the PRT system is to be elevated and thus will have a minimal effect on capacity of the road network.

4) CyberCars in the TASS5 model

CyberCars where to "straighten" bus routes that make detours to increase coverage. Circle route 20 and 60 were chosen. The introduction of a CyberCar system would reduce traveling time with 5 minutes for both routes. Before implementation of the CyberCars the routes take 33 and 34 minutes to complete a one loop.

It was attempted to use the same strategy as in the MARS model where by the CyberCars are modeled as a reduction in walking. For the public transport network a set of new walking links where created. The distance of the link was calculated as to give and the same walking time as time spent in the CyberCar. The CyberCar is 6 times faster than walking hence the walking links where give 1/6 of their actual distance. As in the MARS model the effect of CyberCars on other traffic was not modeled.

V. Lessons Learnt from Modelling the New Solutions

PRT and CyberCar sound generic, but as shown earlier in the text great differences in mode of operation, amenities and safety/security can exist. One has to go into detail about the application of each system to be able code the systems. Especially mode of operation attributes can influence perception of the service and actual performance. One worrying issue is that the capacities of new solutions are not taken into account. This is especially troublesome since we were only using attributes affecting performance to describe the systems. Both in the MARS and TASS5 model the new solutions have no capacity restraint.

For MARS and TASS5 external tools had to be used to generate input data. A large degree of preprocessing dependant on attributes of the new systems is a sign that the models are not mature for this type of problem. For models to be used in a production environment for planning purposes it would be advantageous if there was little attribute dependant preprocessing.

Preprocessing is not merely data collection, but calculations based on attributes of the systems. E.g. in the case of PRT for the TASS5 model mode of operation determined how the data was to be created. If a line-haul mode of operation was to be used during rush hour then the PRT system would be coded as a single buss-route. Preprocessing based on attributes was used for both solutions and both models. Thus to be able to use the models and test scenarios with different attributes planners will need the preprocessing tools and a description of the methods used to create the input data.

The scale of the new solutions compared to zone size can also be challenging. If the model does not have a network description one is left with educated guessing, unless a network is created in the preprocessing stage. In the MARS model this became evident when it came to creating the distance matrix for the PRT system. One zone will contain many stops. The task of finding an average travel distance for all PRT users in this zone was eventually based on an educated guess.

VI. Modelling Results

The two models give a large array of results for each alternative. The TASS5 model can give traditional

[7] Python is a free programming language with a large community that develop a wide set of free libraries, http://www.python.org/

results as mode split, travel time and volume on links in the transport network. The MARS model can give results at a higher level of aggregation such as corridor or area wide. But on the other hand the model has more indicators such as calculation of emissions, energy usage, accidents and noise.

Since none of the models have been created with new transport solutions in mind caution should be used when using these results. The MARS model is not capable to calculate the effects of the straightening of lines with a CyberCar feeder system. The total vehicle kilometers traveled by PT is used to calculate PT emissions. Thus emissions will be overestimated. On the other hand emissions and energy use by the CyberCar is none existent since CyberCars were modeled as a reduction in access time.

The TASS5 model does not calculate emissions, but can feed results into a cost benefit tool that can calculate emissions. The proxy method that was used to model PRT could seriously distort results. The "trick" to model PRT as direct bus routes with only 1 minute headway will give to many PT kilometers. Post processing of model results before feeding them into the cost benefit tool will be necessary.

Mode split is one common indicator which both models produce. An increase in PT share can support an argument that one has created a new transport solution that is more attractive. Thus if both models show a large increase PT usage then one can say that new solutions can move the humans away from their beloved cars.

A. Mode split results

Model-wide mode split results were not used since the TASS5 covers a larger area than the MARS model. Instead relations between two MARS zones where chosen and TASS5 data was aggregated to this level. For the CyberCar case movement from zone 1 to 13 was chosen. This is from a largely residential area to the city centre. For PRT movement from zone 23 to 24 was chosen. This is between two zones where the PRT links two university campuses, Gløshaugen and Dragvoll.

Table 2 shows the volumes by modes the models reported traveling from zone 1 to 13. The BAU (Business As Usual) case is that base that new solutions are compared with. It is worth noting the large discrepancy between the two models. The TASS5 model is reporting approximately 4 times larger volumes. The mode split seems to be a bit different. Model-wide mode split was calibrated to the observed mode split in Trondheim. For this zone relation it seems like too many are taking the car instead of walking in the MARS model.

	MARS		*TASS5*	
Mode	**BAU**	**CC**	**BAU**	**CC**
Slow	53	51	1071	1028
PT	98	118	240	298
CAR	541	540	1135	1132
Total	692	709	2446	2458

Table 2 CyberCar, passengers from zone 1 to 13

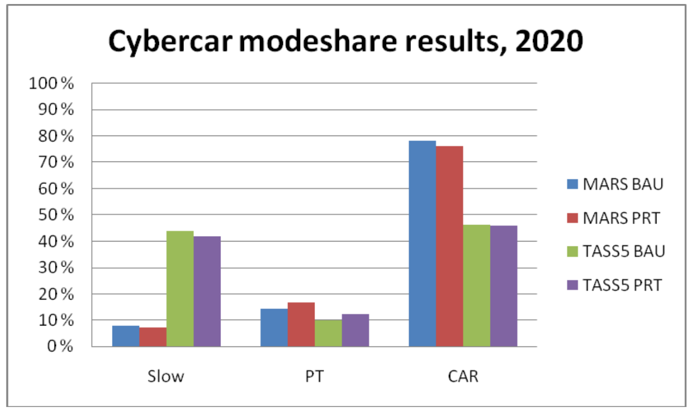

Figure 4 CyberCar mode share, year 2020

After introduction of the CyberCar one can observe small changes in mode split. In both models there is an increase in the use of public transport. Looking at the absolute numbers in Table 2 one can see that the introduction of a CyberCar system has increased the number of travelers from zone 1 to 13 in the MARS model. The new travelers seem to choose the PT system. In the TASS5 model there seems to be redistribution from slow modes to taking public transport if a CyberCar feeder system is introduced. In both models car usage is unchanged.

The introduction of a PRT system shows an increase in the number of travelers between zone 23 and 24. The PRT increase in the MARS model was about 40% while for CC the increase was under 3%. For the TASS5 model the increase for both scenarios was under 1.5%.

There is quite a difference in the mode split between the two models. Slow modes seem to be under represented in the MARS model. Table 3 presents the volumes moving between zone 23 to 24.

	MARS		*TASS5*	
Mode	**BAU**	**PRT**	**BAU**	**PRT**
Slow	31	29	405	342

PT	28	25	155	274
CAR	183	177	910	873
PRT	0	106	0	0
Total	242	337	1470	1489

Table 3 PRT, passengers from zone 23 to 24

Table 3 shows and interesting growth in the total number of travelers for the MARS model, just under 40%. This may be due to a modeling artifact. The MARS model builds on the assumption of a constant travel time budget. Thus the faster you travel the longer or more you can travel. This is thought to be causing the growth in trips taken. I have not succeeded in finding real world results showing an increase of this magnitude solely due to the introduction of a new mode of transport.

Figure 5 shows how the mode split will be affected by introduction of a PRT system. The MARS model has a separate mode for PRT while in the TASS model PRT is part of the PT mode.

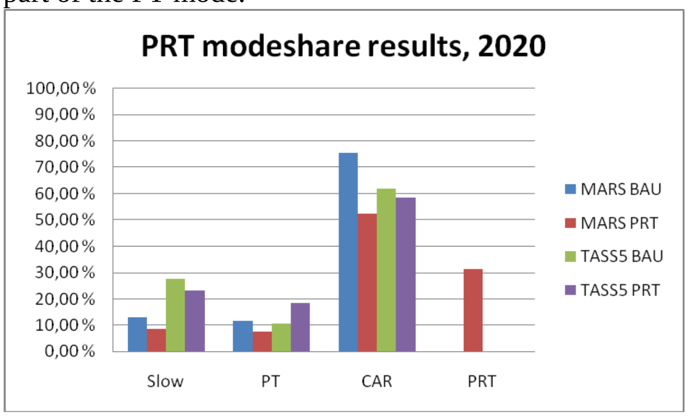

Figure 5 PRT modeshare, year 2020

The graph and table for PRT suggests that PRT can move travelers away from the car, but still users will be taken from the slow modes. This is very evident in the TASS5 model where there is only a small increase in the number of trips on the studied relation, Slow mode has a 15% reduction while PT has an increase of 76% which is quite impressive.

It should be noted that design differences in the models can be causing the different growth in the number of trips. For a TASS5 model the total amount of trips are independent of accessibility measures. Only demographic data are used as input in the trip production phase. While in MARS model the total number of trips can grow because of the earlier mentioned constant travel time budget assumption.

The changes between the modes are quite big, and the overall trend seems to be a reduction in car usage. But the picture is not all that clear. The TASS% model predicts a 15% reduction in slow modes while the reduction in car usage is 5%. The MARS model also gives a 5% reduction in car usage, but a stabile share for slow modes. The massive increase for PT in the MARS (468%) model is unrealistic, but the 76% increase in the TASS5 indicates that the new technologies can be very interesting. But one should also be aware of possible effects on the slow modes causing quite large reductions.

One weakness of the way new systems were tested was the assumption of unlimited capacity of the new systems. Since modeling was done on basis of performance attributes the results can possibly be optimistic because of the unlimited capacity assumption of the new systems.

VII. Conclusion

This paper has looked into modeling new transport solutions with existing transport models. The first part of the paper looked at the new transport solution. Within the groups of PRT and CyberCar quite different types of systems can exist. The mode of operation can change with the flick of a switch. The PRT system in Morgantown can switch between line-haul and point-to-pint mode in response to demand. For strategic decisions one needs to look at the details of the systems. Different modes of operation can lead to different implementations of the system in the models. There still needs to be done work on how users perceive other attributes not directly related to system performance such as amenities and privacy/security attributes.

One way to think of maturity of models to a specific task is to look at the amount of pre and post processing of data needed. Both the MARS model and the TASS5 model need preprocessing of input data based on attributes of the new transport system. Both models were able to give mode split results without post processing.

While post processing was not needed for mode split results it is important to note that exiting links to post processing tools can be broken. Not broken in the sense that the tools do not work. But the results are bogus because of the "tricks" used to implement the new solutions.

The results from the testing of the two new transport solutions seem to indicate that mode split changes are small. This seems sensible since we approximate the new solutions to exiting solutions for the attributes not related to performance.

One possible way to go from here is to look how existing transport models can be made more robust for evaluating new transport solutions. Especially reducing the amount of attribute influenced preprocessing of input data. Important results as emissions should be looked at closely as they are likely to be effected by any “tricks” used in the implementation phase. It is also important to ensure that links to existing post processing tools are not jeopardized.

More work is needed to get models that can feed results directly into the planning process. Both the TASS5 and MARS model can serve as starting points, but the focus should be to integrate the preprocessing needed for the new transport solutions into the models. Attention should also be paid to indicators such as emissions. Do the models or their post processing tools give sensible results for these indicators?

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