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Making Travel inside Central Business Districts Efficient Using Accelerating Moving Walkways and Periphery Parking Framework

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ABSTRACT

The dense central business districts which are often the city centers are getting extremely crowded and vehicles are taking up a lot of crucial space which can be utilised for other activities. These central business districts are often the economic engines of the city and they house the major business and markets. Car Parks and vehicular movement take up a substantial amount of high value real estate which can be better utilised for other economic activities. These dense central business districts are also heavily polluted by low air quality and high vehicular noise pollution. High pollution levels, traffic jams, road rage, difficulty in finding a parking spot etc. make central business districts a difficult place for any city dwellers. The key thought of this examination is to ideate a combination of Accelerating moving walkways (AMWs) with the periphery parking framework as a viable solution for the decongestion of the city centers and make travel faster. The goal of the research is to make travel faster and more efficient with AMWs, as a solution for traffic in central business districts, and thereby reclaiming the streets for the people.

Keywords: Moving walkways, Smart cities, traffic decongestion, Periphery parking, novel transportation

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Introduction

Problem Statement

The dense central business districts or the city centers are dealing with the problem of overcrowding and vehicles are taking up a lot of limited space which is already in high demand and is scarce. These central business districts are often the economic centers of the city and they house a lot of business, markets, institutions etc. Car parks and vehicular movement take up a substantial amount of high value real estate which can be better utilised for other purposes. These dense central business districts are also heavily polluted by low air quality and high vehicular noise pollution. High pollution levels, traffic jams, road rage, difficulty in finding a parking spot etc. make CBDs a crowded and an inefficient place of the city and its residents. Private vehicles are regarded as a symbol of luxury travel providing freedom of movement but they do cause substantial constraints in available space inside the city centers. Public transport along with the private vehicles have not been able to decongest the city centers and are not able to sufficiently handle the fast growing footprint of the areas. There exists a need to make transportation sustainable and also accommodate the ever growing CBDs.

Making inter-city travel faster will contribute to making traveling efficient. One of the key research questions the paper aims to answer is "Can using the AMW network make travel faster inside city centers during peak times?"

Figure 1. *Image Depicting the Traffic Problems in the City Center of Bangalore*

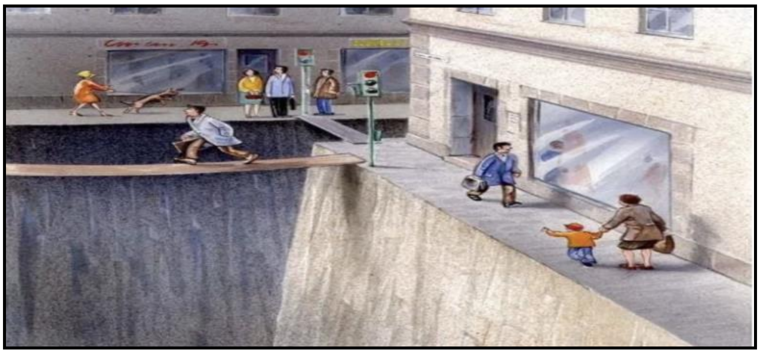
Source: unsplash.com.

Motivation

There is a pressing need to reclaim these parts of the city from the scourge of vehicles. We wanted to make central business districts easily accessible for all and allow people to have more pleasant experiences while visiting these locations. Another crucial need is to prevent traffic choke points for vehicular movement through central business districts. Due to the dense nature of central business districts vehicles passing through the central business districts often get caught into long winding traffic jams. We have personally experienced this many times living in the bustling city of Bangalore. There exists certain choke points inside the city which are oftentimes riddled with traffic jams.

We wanted to solve the traffic problem our city faced and have identified a solution which addresses the concerns of a growing and an urban city like Bangalore. The following image perfectly captures our concern.

Figure 2. *A Swedish Artist's Rendition, Representing the Space we have Surrendered to Vehicles*



Source: Karl Jilg/Swedish Road Administration.

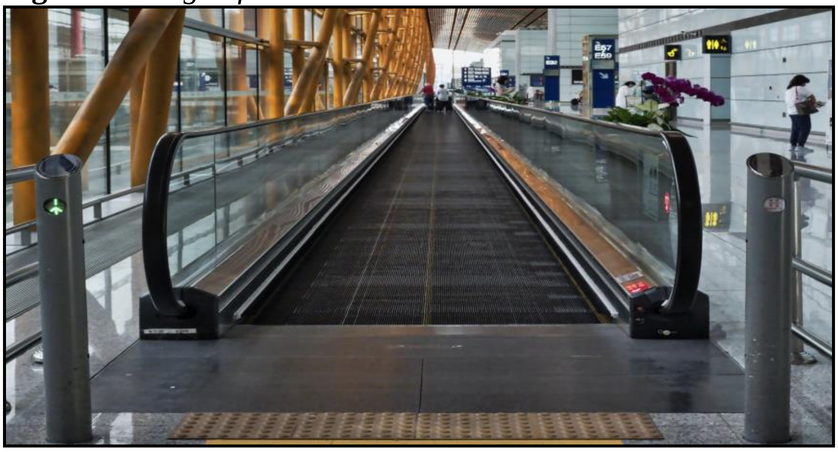
Literature Review

In this section we will try to provide a background of the work which has been carried out in this domain. We will explain the workings of an AMW and share some practical examples of places where this technology has been deployed.

Accelerating Moving Walkway

Accelerating Moving Walkways or AMWs are transport frameworks that continuously move passengers by accelerating them from a relatively low speed at the entry to a higher speed at the middle section, and then decelerating them to a relatively low speed again at the exit. This variation in speed allows for ease in embarking and disembarking while maintaining good overall speed of transportation.

Figure 3. *Image of an AMW*



Source: unsplash.com.

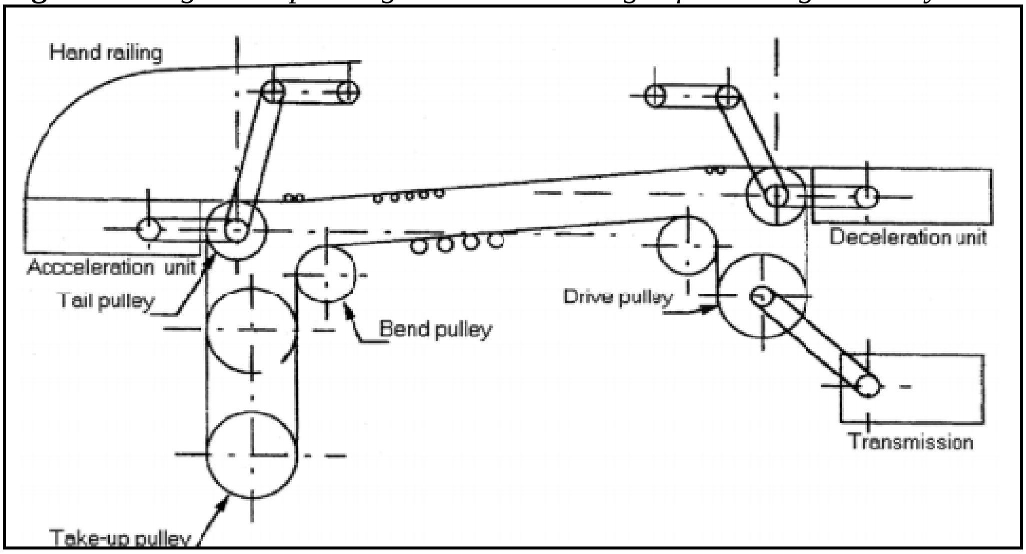
These systems were developed with the aim to fulfil the demand for a people mover that can bridge the gap between short and medium distance transport.

There are a number of different ways in the manner the pallets slide on the belt. One system accelerates and decelerates each main pallet by sliding them over continuous auxiliary pallets. Another design used an array of pallets that slightly overlap one on top of the previous at the entrance, each of which then progressively slides forward to accelerate passengers. These two systems were only tested in the factory. The more successful variation is the TurboTrack system, which employs auxiliary pallets and main pallets. The auxiliary pallets ‘hide’ underneath the main pallets at the entrance and exit, and progressively extend or retract to accelerate or decelerate the passengers. The auxiliary pallets are fully extended at the high speed section, forming a continuous treadway with the main pallets.

<u>Main Components</u>

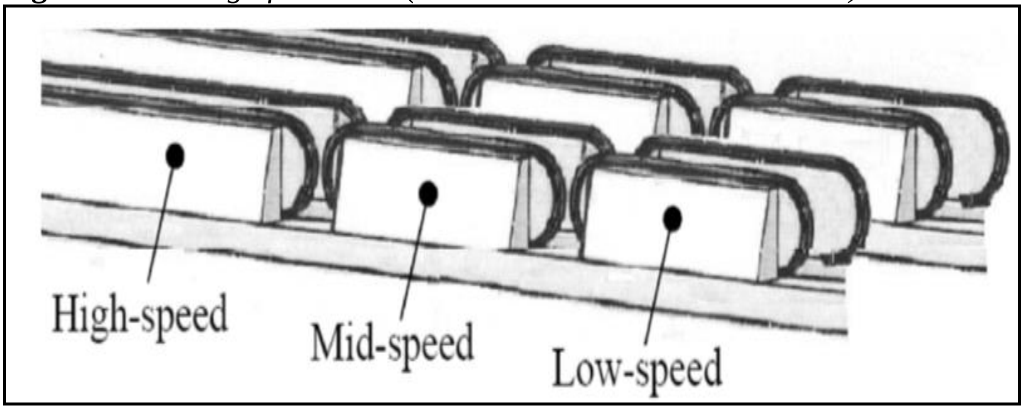
The AMW can be distinguished into three major parts: the accelerating and decelerating rollers, the high-speed belt conveyor, and the handrail. Each major part has its own mechanism, but they all work synchronously. We consider two different speeds primarily for embarking/disembarking and the middle acceleration part. Acceleration is achieved by having different belts rotate at different speeds until the desired acceleration or the final velocity is achieved. This is done keeping in mind the safety of the passengers while embarking and disembarking. Getting on or off the walkway at high speeds can disorient the passenger and may result in accidents. The entry and exit speeds are set at 2.52km/hr or 0.7m/s.

Figure 4. *Diagram Explaining the Inner Workings of a Moving Walkway*



Source: Luiting Maten and Lodewijks 2002.

Figure 5. *Working of an AMW (How the Acceleration is Achieved)*



Source: Adapted from Loder 1998.

Types of Moving Walkways

- Belt-type moving walkway (MW)
    - It's a type of travel belt with a rubber band, actually a conveyor belt. Belt-footed species can also tend, too, or become flat, then inclined.
- Pallet-type moving walkway (MW)
    - Pallet walking type is the most common type of paved walking path today. The palettes are metal, and trackable. Pallet type pedals can be tilted, and even flat, then inclined.
- Glidepath Glidewalk moving walkway
    - This type of pedestrian crossing is a cyclic pedestrian crossing, which can turn multiple times. This 4-lane, wheelchair-accessible travel system keeps you on track.

Examples of Installed Moving Walkways

- Turbo track Toronto, Canada
    - Toronto's International Airport was the first to install a new automatic passenger system. It allows continuous transport without waiting times and, because it travels much faster than normal travel, helps passengers overcome a common problem at most airports - long distances to cover.
- Gateway Paris Moving Walkways, France
    - The most famous and expensive installation in history was the travel platform. The walking path included three high platforms - the first was static, the second was at moderate speed, and the third at six miles an hour. This integrated walkthrough is designed for use as hands-on. This hiking trail is similar to the Glidepath Glidewalk hiking trail.
- Domain Express Walkway, Australia
    - It is one of the longest travelators in the world located in Hyde park, Sydney, Australia. It is built underground and passes through a tunnel with murals created on the walls. It has two walkways, each going in opposite directions catering to both the incoming and the outgoing traffic. It also has a car park built at its entrance.

Periphery Parking Framework

To achieve the goal of making the central business districts vehicle free, one major task is the relocation of parking spots scattered in the inner centers, which results in people driving around the center looking for a place to park. Lack of availability of parking spots sometimes results in people double parking and parking in front of gates.

A possible solution is a periphery parking framework, which concentrates the available parking locations into a hub of spots on the outer border of the CBD. A possible solution is a periphery parking framework, which concentrates the available parking locations into a hub of spots on the outer border of the CBD. Cars or any other passenger vehicle must stop and park at one the many parking hubs or complexes and the passengers must disembark onto the network of AMWs to continue with their journey to the destination. Existing roads will be used only by emergency vehicles and building/maintenance vehicles. Private vehicles will not have access to city-centers roads. Examples of cities that have the periphery parking systems are Pittsburgh, Pennsylvania; St. Paul, Minnesota; San Jose, California etc. However, this may decrease the level of accessibility as we moved the parking location away from the final destinations. This hurdle is overcome using the wide network of AMWs for the last mile connectivity. In Bangalore itself, people find it very difficult to park their vehicles because of the narrow roads. Roadside parking is a necessity in any city’s traffic ecosystem. Unfortunately, it is so underrated when compared to bigger problems that it gets sidelined. Given the high percentage of four-wheelers among the total vehicular population in Bangalore, it becomes paramount to be able to manage the availability and proper utilisation of parking spaces on the main arterial roads of the city. The periphery parking hub is to be located within a high traveling density area and located at the spots where roads are congested, in order to help with decongestion. It should be located at the location where the prices of land are less than that inside the city centers to allow for cheaper cost of procuring the land, for construction of the parking hubs. Periphery parking framework significantly reduces the number of vehicles plying inside the city centers.

Parking Problem in Bangalore

Bangalore has the unfortunate distinction of having the highest vehicles per capita in the entire country. To put it in layman's terms, there are more vehicles per every 1,000 people compared to many of its peers. For every 1000 people in the city, Hyderabad has 440 vehicles, Chennai has 435 vehicles, Delhi 448 vehicles. Bangalore ends up struggling with about 488 vehicles for every 1000 people living in the city. Adding to these numbers a very high percentage of almost 20% of traffic consists of four-wheelers which demands a much larger space for parking these long vehicles. Management of parking space hence is a crucial element in solving traffic problems.

Traffic delays in Bangalore are due to various reasons like narrow roads, slow traffic flow, insufficient signal light coordination, rash driving, people breaking traffic rules etc.

In Bangalore places like Marathalli, Indiranagar, JP Nagar, Jayanagar, Bangalore Fort, MG road, Vijaynagar , Rajajinagar, Malleshwaram , RT Nagar, New Bel road, KR Market, Maruthi Mandira, Avenue road, chickpet, Cubbonpet, Bangalore palace are the most crowded places in Bangalore. These areas mainly face most traffic issues. According to Times of India, Bangalore parking is 6th worst in the world. This is mainly due to lack of parking spaces. On average it takes about 20-30 minutes to find a spot in the main areas of Bangalore which is the 4th worst waiting time in the world. And the state is getting worse day by day. Almost 30% of the traffic comprises 4 wheelers. Installing AWMs will solve the pollution problems as well as the traffic problems. The boom in the IT sector in Bangalore has been the prime reason behind the increase in pollution. Apart from this another setback for the urban parking system in India is vehicle towing. As per Times of India report (July 2019) in Bangalore only 8 vehicles are towed per day (Source: Times of India) which is very less when compared to the number of illegally parked vehicles on the road. The main reason behind this is that there are no strict policies for this and the lack of resources. Our model of the periphery parking system along with AWMs will solve this problem because no vehicle will be allowed inside the central business districts.

Cities from all over the world like New York, Boston, London, Hong Kong have already reformed their urban parking policies to improve the parking methods. India on the other side is still quite far behind in reforms when compared to these countries in terms of city parking methods. Indian government has instituted parking tickets to help with this problem but the main issue with this is that the ticket prices are very less than the value of land these vehicles are parked on. People pay the fines when caught and continue to flout the rules since the penalty isn't significant. Parking rules are not strict, enforcement is very weak. People park their vehicles wherever they want to. Even public transport's revenue collection is very less due to poor pricing and the maintenance cost expense of those vehicles.

Methodology

The traffic/map application developed by Google, called Google Maps was used as the base to build the AMW networks. Average peak traffic and population, business, shops density was used as metrics to classify a location as city center/CBD. The width of the roads, presence of places like education institutions, religious gatherings, office parks/buildings, markets etc. were taken into consideration while designing the network of the walkways and the nodes.

To calculate the time required for travel during the peak business hours, average morning and evening peak hours in slots of 0.5 hours were taken. Total of 6 slots were considered, 3 in the morning and the rest in the evening of a typical workday. The travel time data was collected from the application. This application provided the most reliable and recent traffic data. In addition the speed of the passenger on the accelerating moving walkway was considered as 14km/hr ie. 5km/hr as the speed of the walking passenger and 9km/hr as the speed of the walkway.

The data obtained for travel times depending upon the distance was then used to compare the time efficiency between the three modes of transportation namely AMW, cars and public busses.

Proposed Solution

Designing of the Parking Hubs

The first step to make parking efficient is to find a balance between parking supply and parking demand. There should not be more parking areas then required.

- We need to audit the whole area to find out about the parking demand. Getting the data from reliable sources will also help. A zone wise parking survey will be a good method. To insure zone wise parking surveys:
    - We propose an 18 hour survey of the number of vehicles using the parking zone during this interval. Then we will note down the average time these vehicles are parked there.
    - By looking at the demand we will set the parking fee and determine the number of parking hub spaces which needs to be built.

Now as we know that each area has different traffic congestion so we will be calculating this for every area. Although some areas have parking shortages, if there is a parking zone available within a reasonable walking distance then this will also be kept in mind while planning the implementation.

Parking Fee

Parking fee should be in proportion to the existing parking fees charged in the parking locations inside the city centers. Fee should be in proportion to the time the vehicle is parked. Fee for 2-wheelers should be less that of the 4-wheeler fee. Parking revenue collected should be reinvested into building and maintaining the parking hubs.

Implementation

The Periphery Parking Framework needs to be efficient in order to prevent traffic jams and roadblocks at the entry and exit points of the network. We propose the use of following methods in order to achieve the desired efficiency:

- Staggered timing slots to reduce clogging.
    - This will allow for rush hour office traffic to move smoothly. Bangalore being the IT hub of India gets most of its traffic due to people going to and coming back from their work. One solution to this problem is by providing staggered timing slots to each company. Every employee of that company will be given a time slot according to their shifts. They will have to follow that timing slot to enter and leave the parking hubs. The first one to enter the parking hub will be the first one to leave as well.
- VANETs (Vehicular ad-hoc networks) to make parking efficient.
    - VANETs consist of groups of moving or stationary vehicles connected by a wireless network. VANETs consist of two major parts namely OBU (on board units) and RSU (Road-side units). They help with parking assistance and locating the nearest available parking lot. They will allow the driver to locate the vacant parking spots and also assist in parking the vehicle into the parking spot.
- Using multilevel car parking
    - Multi-Level parking will allow us to better utilise the space constraints. This is an available technology which will be implemented to make the periphery parking framework more efficient while also providing significant cost savings in building the parking complex. One of the earliest multilevel parking concepts was implemented in Chicago in 1918.
- Using RFID tag for automated toll collection.
    - This will allow for faster checkouts and reduce wait times for vehicles. RFID tags are simple to use. They can be reloaded and also allow for automatic deduction of parking charges and allow the vehicle to pass through the collection both without stopping for

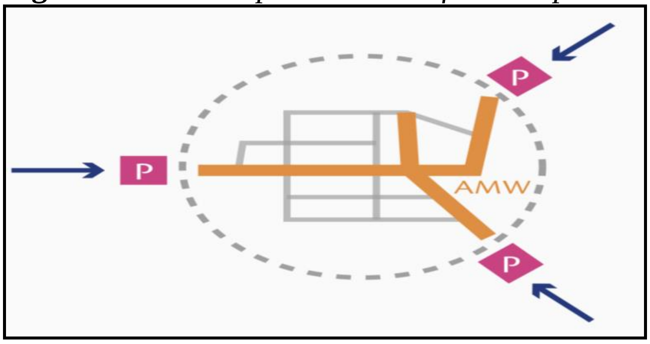
the cash transactions. RFID tag will be linked to a prepaid account from which the parking fee is deducted. The tag is affixed on the vehicle's windscreen after the tag account is active. This is a good solution for a clutter free interaction with the parking framework. This will help save time, need for paper receipt generation and middle man.

- Monthly/Yearly passes for money collection will allow for better revenue collection and prevent the hassle of reloading money often.
- Separate parking space for two-wheelers and four-wheelers.

To determine the capacity of the parking hubs we propose a survey to calculate the number of cars/vehicles parked inside the central business district during the peak hours. Based on the data collected the periphery parking hubs are to be constructed. The hubs could utilise existing infrastructure or build new ones at the periphery of the AMW network.

Network

Figure 6. *Visual Representation of the Proposed Solution*



Source: Transport and Mobility Laboratory – EPFL.

To achieve a vehicle-free city center an alternative to vehicles must be provided and the network of AMWs will act as one.

Cars or any other passenger vehicle coming into the CBD must stop and park at one the many parking hubs or complexes at the outskirts and the passengers must disembark from the vehicles and get onto the network of AMWs to continue with their journey to the destination. A key concern of variable demand would arise during the morning and evening peak business hours. During the morning peak times the number of AMWs entering the CBD will be greater than the number of walkways exiting, this will allow for the increased demand during the morning and evening peak times of people visiting the various shops and business. Existing roads will be used only by emergency vehicles and building/maintenance vehicles. Private vehicles will not have access to city-centers roads. The network shall be connected with the existing public transport infrastructure to provide for greater connectivity and mobility. This will allow us to further limit the use of private vehicles for intra-city transportation.

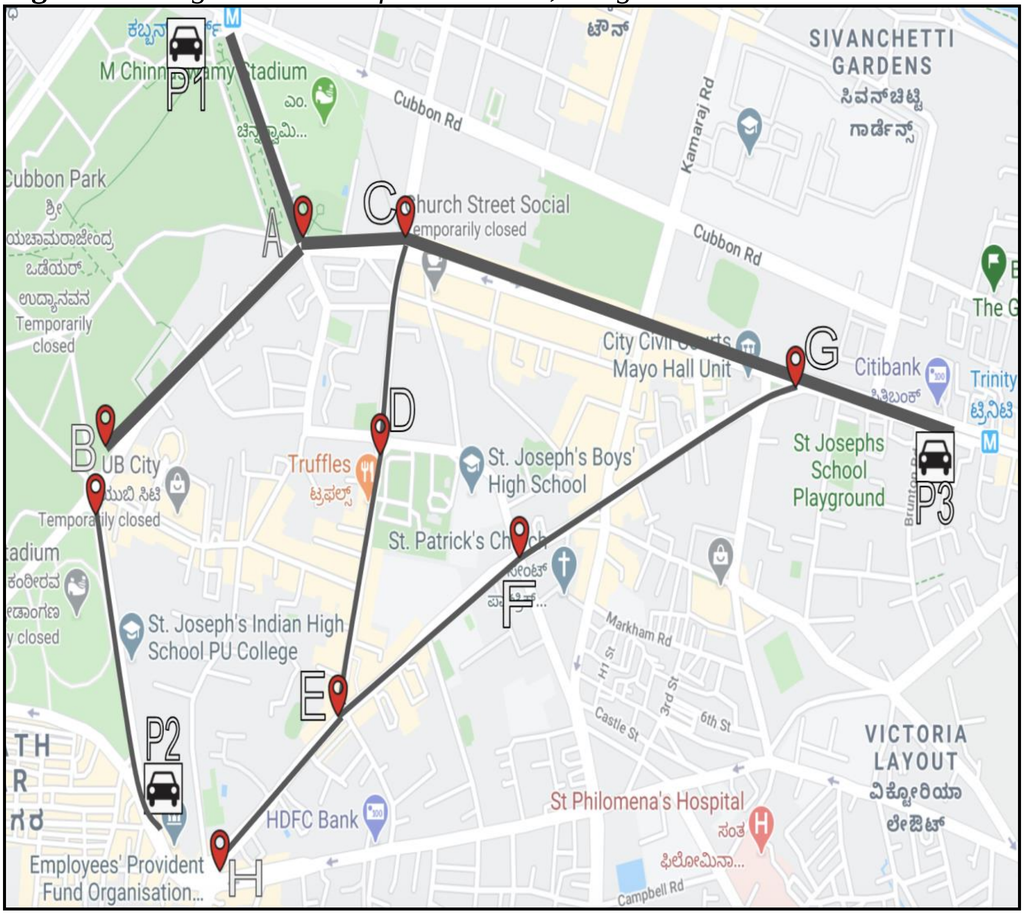
Figure 7. *Symbol Depicting the System of Periphery Parking Framework and AMWs*

Source: Svehicleinci R, Bahrami, Ourednik and Bierlaire M, 2017.

Implementation Details

Network Design

Figure 8. *Designed Network for MG Road, Bangalore*



Source: Prepared by the Authors on Google Maps.

Legend:

 Parking complex

 Node connecting two AMWs

A, B, C, D, E, F, G, H - Nodes
P1, P2, P3 - Parking hubs

Details of the network:

- Availability of three major parking complexes at the periphery of the network.
- Smaller parking locations for two wheelers at the nodes.
- Nine nodes provide for embarking and disembarking.
- Total distance: 5.89 km (3.66 mi).
- Average speed of moving walkway: 9km/hr. Average walking speed considered: 5km/hr.

This location was considered for the following reasons:

- Connectivity via the metro rail system.
- High density of business, shops and office spaces.
- Availability of relatively wider roads, problem of street/road parking plagues the area.
- Major choke point for intra city travel during the peak business hours.
- Relatively high per capita income to absorb the expenditure burden of implementing the proposed system.

Once we narrowed down to this location, we calculated the typical travel times during morning and evening peak hours for cars and buses and compared them with the travel time when using AMW (Table 1). This analysis was done for three other locations in Bangalore namely: Indiranagar, Basavanagudi and RR nagar.

Time Calculation and Comparison with Other Modes of Transportation

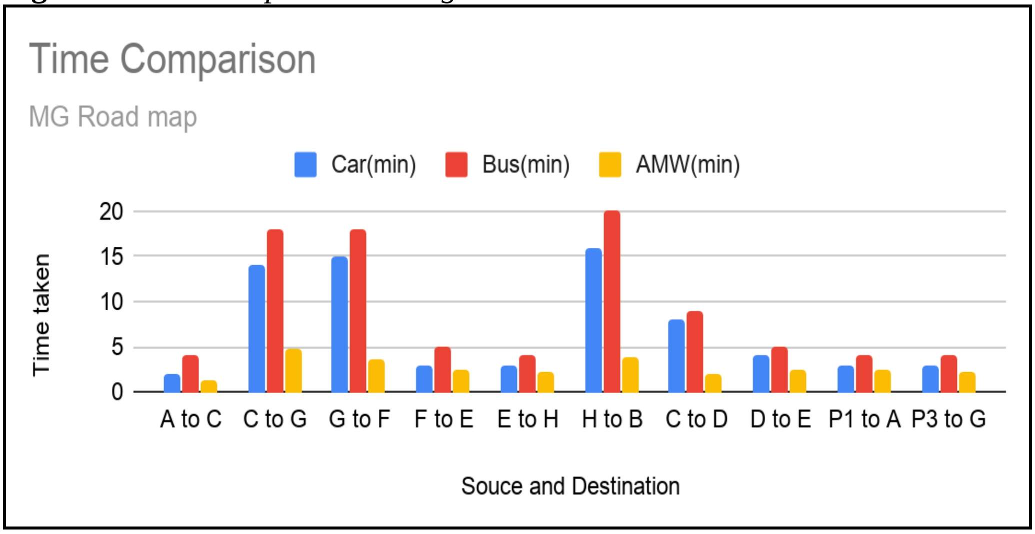
For AMW we considered an average speed of 14km/hr and the time for embarking and disembarking were considered negligible.

Table 1. *Average Travel Times between Nodes*

Source and Destination	Distance (m)	Car (min)	Bus (min)	AMW (min)
A to C	300	2	4	1.29
A to B	750	3	5	3.21
C to G	1100	14	18	4.71
C to D	450	8	9	1.93
B to P2	900	6	7	3.86
G to F	850	15	18	3.64
F to E	600	3	5	2.57
E to H	500	3	4	2.14
H to B	900	16	20	3.86
D to E	550	4	5	2.36
P1 to A	550	3	4	2.36
E to P2	550	3	5	2.36
P3 to G	500	3	4	2.14

Source: Calculated by the Authors based on Typical Travel Time Data from Google Maps.

Figure 9. *Time Comparison during Peak Times*



Source: Prepared by the Authors based on Data from Table 1.

Figure 10. *Designed Network for Indiranagar, Bangalore*

Source: Prepared by the Authors on Google Maps.

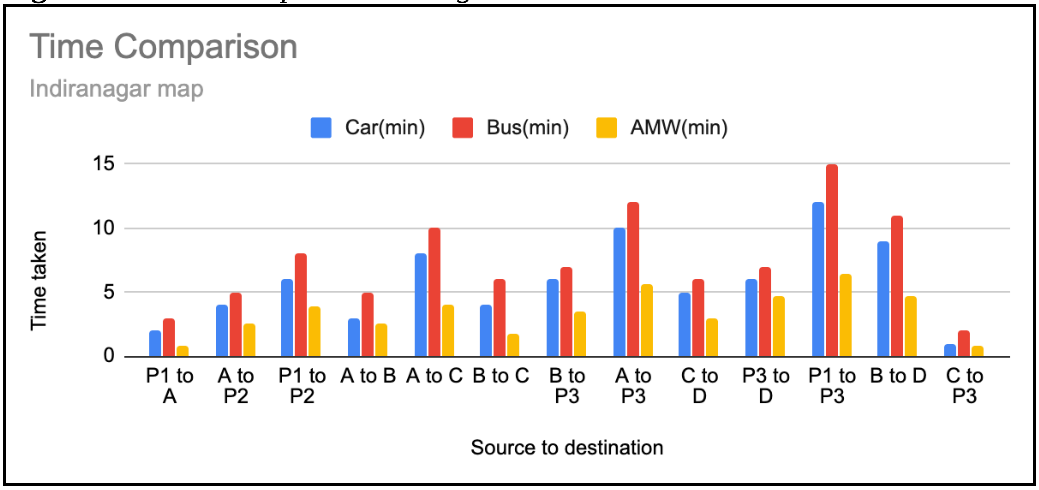
Total length of the network: 2.63 km

Table 2. *Average Travel Times between Nodes*

Source and Destination	Distance (m)	Car(min)	Bus(min)	AMW(min)
P1 to A	200	2	3	0.857118368
A to P2	600	4	5	2.571355104
P1 to P2	900	6	8	3.857032656
A to B	600	3	5	2.571355104
A to C	950	8	10	4.071312248
B to C	400	4	6	1.714236736
B to P3	800	6	7	3.428473472
A to P3	1300	10	12	5.571269392
C to D	700	5	6	2.999914288
P3 to D	1100	6	7	4.714151024
P1 to P3	1500	12	15	6.42838776
B to D	1100	9	11	4.714151024
C to P3	180	1	2	0.7714065312

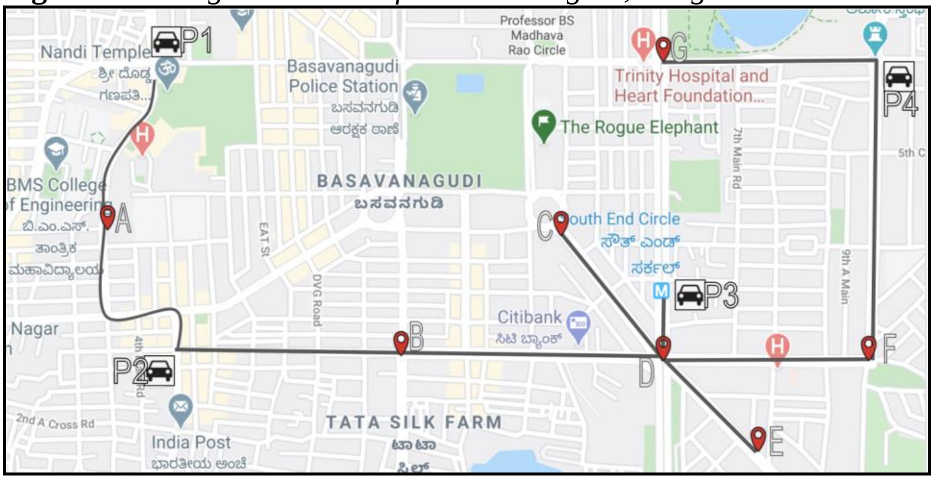
Source: Calculated by the Authors based on Typical Travel Time Data from Google Maps.

Figure 11. *Time Comparison during Peak Times*



Source: Prepared by the Authors based on Data from Table 2.

Figure 12. *Designed Network for Basavanagudi, Bangalore*



Source: Prepared by the Authors on Google Maps.

Total length of the network: 5.15km

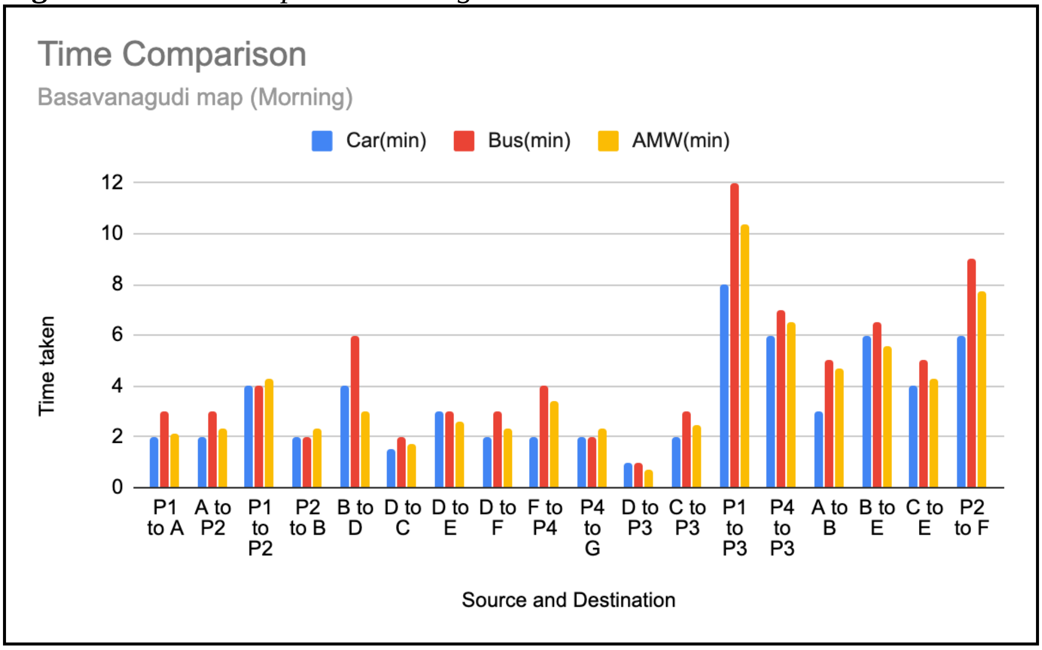
Table 3. *Average Travel Times between Nodes*

Source and Destination	Distance (m)	Car(min)	Bus(min)	AMW(min)
P1 to A	500	2	3	2.14279592
A to P2	550	2	3	2.357075512
P1 to P2	1000	4	4	4.28559184
P2 to B	550	2	2	2.357075512
B to D	700	4	6	2.999914288
D to C	400	1.5	2	1.714236736
D to E	600	3	3	2.571355104

D to F	550	2	3	2.357075512
F to P4	800	2	4	3.428473472
P4 to G	550	2	2	2.357075512
D to P3	170	1	1	0.7285506128
C to P3	570	2	3	2.442787349
P1 to P3	2420	8	12	10.37113225
P4 to P3	1520	6	7	6.514099597
A to B	1100	3	5	4.714151024
B to E	1300	6	6.5	5.571269392
C to E	1000	4	5	4.28559184
P2 to F	1800	6	9	7.714065312

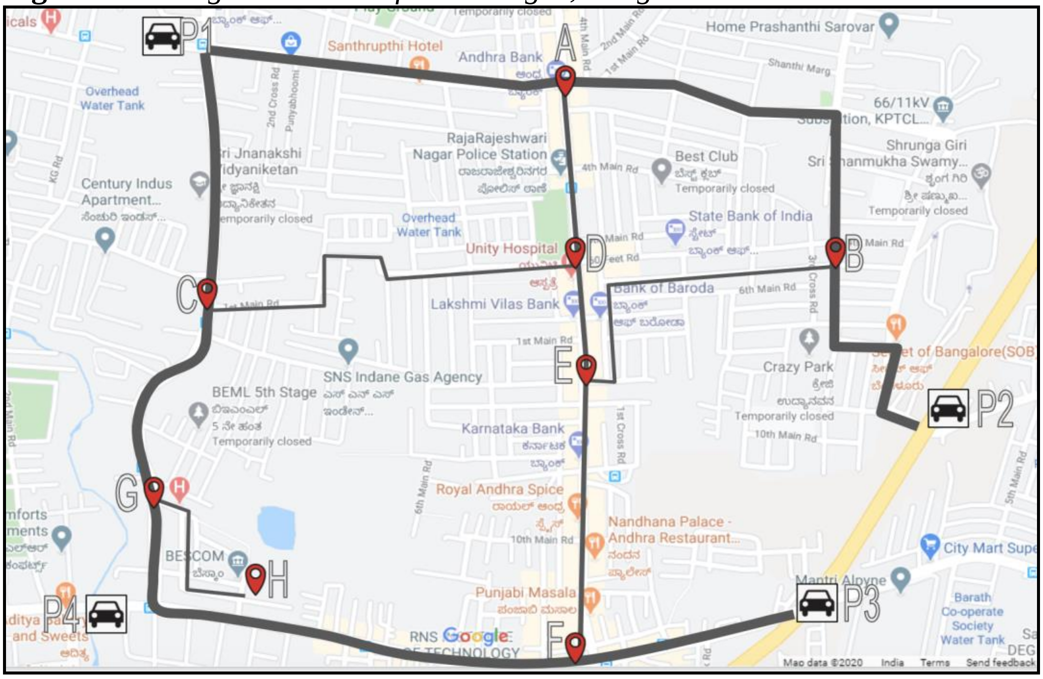
Source: Calculated by the Authors based on Typical Travel Time Data from Google Maps.

Figure 13. *Time Comparison during Peak Times*



Source: Prepared by the Authors based on Data from Table 3

Figure 14. *Designed Network for RR Nagar, Bangalore*



Source: Prepared by the Authors on Google Maps.

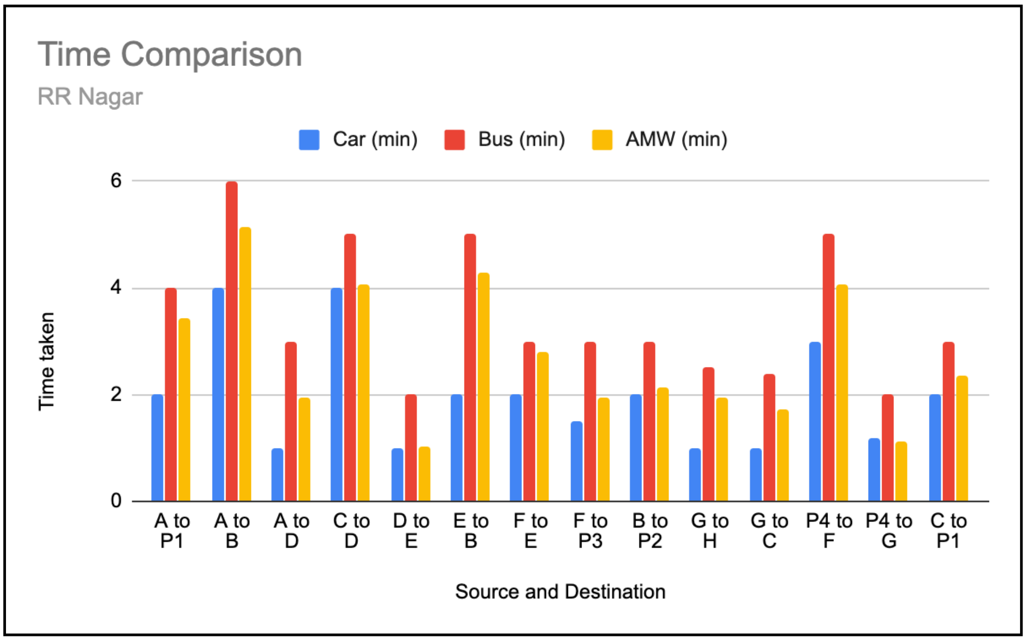
Total length of the network: 8.850km

Table 4. *Average Travel Times between Nodes*

Source and destination	Distance (m)	Car (min)	Bus (min)	AMW (min)
A to P1	800	2	4	3.43
A to B	1200	4	6	5.14
A to D	450	1	3	1.93
C to D	950	4	5	4.07
D to E	240	1	2	1.03
E to B	1000	2	5	4.29
F to E	650	2	3	2.79
F to P3	450	1.5	3	1.93
B to P2	500	2	3	2.14
G to H	450	1	2.5	1.93
G to C	400	1	2.4	1.71
P4 to F	950	3	5	4.07
P4 to G	260	1.2	2	1.11
C to P1	550	2	3	2.36

Source: Calculated by the Authors based on Typical Travel Time Data from Google Maps.

Figure 15. *Time Comparison during Peak Times*



Source: Prepared by the Authors based on Data from Table 4.

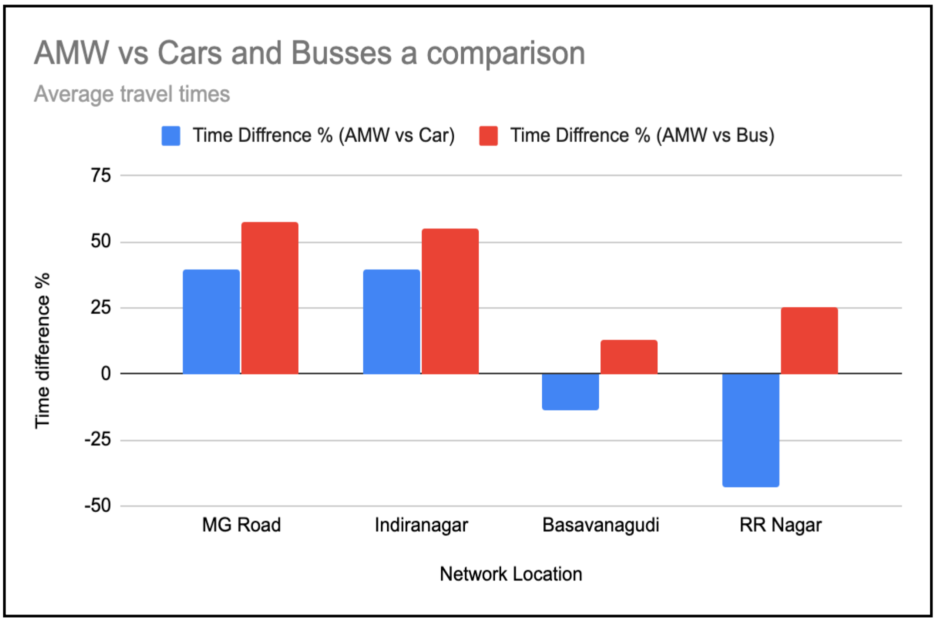
Findings

Comparing time required to traverse the various nodes and parking junctions during peak times we get the following data. The data clearly reflects and proves our hypothesis that the use of AMW reduces the travel time inside central business districts. The charts were analysed to calculate the average % increase or decrease in travel times.

- The designed network for MG Road makes travel faster by 39.5% in comparison with cars and 57.66% faster in comparison with public busses.
- The designed network for Indiranagar makes travel faster by 39.59% in comparison with cars and 54.93% faster in comparison with public busses.
- The designed network for Basavanagudi makes travel slower by -13.95% in comparison with cars and 13.13% faster in comparison with public busses.
- The designed network for RR Nagar makes travel slower by -42.67% in comparison with cars and 25.21% faster in comparison with public busses.

The data clearly reflects and proves our hypothesis that the use of AMW reduces the travel time inside central business districts. The time comparison charts for each location (Figure 9, Figure 11, Figure 13, Figure 15) was used to analyse the average % increase or decrease in travel times. The result of the analysis for the four locations is summed up in the chart (Figure 16).

Figure 16. *Graph Showing Time Difference % between Various Modes and Network Locations*



Source: Prepared by the Authors.

After comparing the four results we can conclude that implementing the proposed research in MG Road and Indiranagar significantly reduces the travel time while for the Basavanagudi and RR Nagar network the travel times have increased. Basavanagudi and RR Nagar (not being city centers) are not the ideal locations for implementing the proposed model and hence there is not a reduction in travel times.

We can conclude that implementing the proposed model of AMWs in the right locations makes traveling inside the central business districts faster, easier and healthier, although the high upfront investment will remain a significant challenge in implementation of the proposed system. As cities are becoming denser, traffic jams, pollution, road accidents, etc. will be on the rise. AMWs along with the Periphery Parking Framework would provide relief in the long term and ease the burden on dense central business districts.

Conclusions

Implementing the proposed model of AMW along with the periphery parking framework can be a good solution to the traffic problem plaguing the CBDs. Reduction in travel times (compared to public/private transport modes) during the peak business hours offer significant incentive to implement the proposed model. There are significant environmental benefits since the AMWs are fully electric and do not cause air and noise pollution. The many health benefits derived from the proposed model adds to the many benefits. It is a flexible public transport system:

- High speed: faster than vehicles during peak hours.
- Less operational constraints: routing stations, and drivers.
- High capacity: 4 times more using half space of private vehicles.
- Active mode: promotes a healthier lifestyle as people walk instead of sitting.
- Environmentally friendly: reduces CO_2 emission substantially when compared to cars and busses.

Future Works

Future research should be done on exploring the cost required, both OPEX and CAPEX, and finding out the on-ground configuration of the AMW network. The cost barrier of implementing the accelerating moving walkways is high when compared to busses and light rail however when we take into account that busses and light rail use existing built infrastructure (roads, streets etc.) the costs might not seem substantial. The tremendous amount of health and environmental benefits offsets the capital outlay in designing and implementing the project. Also the expenditure burden will be borne by the central business district and wealthy cities which are resource rich and are always on the lookout to reduce and manage the ever growing traffic problem in their cities.

On ground configuration based on various factors like geographies, existing infrastructure, available resources, population and traffic demand, and other operational constraints is also important as they will further strengthen the proposal and provide greater backing when the idea is being pitched to the authorities.

Definitions, Acronyms and Abbreviations

- AMW: Accelerating moving walkway
- CBD: Central business district
- VANET: Vehicular ad-hoc network
- OBU: On-board unit
- RSU: Road side unit
- RFID: Radio frequency identification
- OPEX: Operational Expenditure
- CAPEX: Capital Expenditure

References

Bierlaire M, Oyama M. *Design of a car-free city center* URL:https://www.epfl.ch/research/domains/transportation-center/research-overview/mobility-analysis-social-behavior/urban-and-suburban-mobility/design-of-a-car-free-city-center/.

Directorate-General for Environment, European Commision (European Union). *Reclaiming city streets for people: Chaos or quality of life* URL: https://op.europa.eu/en/publication-detail/-/publication/94a8a003-be86-467a-9a85-63a5d52bf7ae.

Kusumaningtyas I. *Mind Your Step: Exploring aspects in the application of long accelerating moving walkways.* URL: http://resolver.tudelft.nl/uuid:dca72eda-de 73-4223-ac26-3052fa32a84e.

Kusumaningtyas, I, Lodewijks, G, (2013). *On the application of accelerating moving walkways to sup- port passenger processes in Amsterdam Airport Schiphol*.

Loder, J, (1998). *The in-line accelerating moving walkway*.

Molyneaux, J, (2018). *Multi-objective optimization of moving walkway networks in transportation hubs*.

PCW, (2015). *Post-Car World: A Trans-Disciplinary Multi-Dimensional Stimulation*. URL: http://postcarworld.epfl.ch.

Svehicleinci R, Bahrami, Ourednik and Bierlaire M, (2017). *An exploration of moving walkways as a transport system in urban centers*.

Svehicleinci R, Markov I, Bierlaire M, (2017). *Network design of a transport system based on accelerating moving walkways, technical report*.