ECO-FRIENDLY CITY

(A BLUEPRINT FOR CAR-FREE CITY)

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Contents

1. Abstract

With the growing human footprint on the planet, it is imperative to develop a sustainable model to ensure our existence for generations together. Factors like excessive land use for residential purposes, carbon emissions from residential, business and transportation must be controlled. Sprawling urban complexes and cities are the fruits of poor city planning, both from housing and transportation perspectives.

An attempt is made in this paper to portray a practical and economical model to get rid of these burning issues, which will help in building next generation cities to house the ever-growing population. This paper discusses a unique, stepwise approach in building a car-free city in contrast to exercising an all-or-none effort. All aspects of City Planning, including Housing, Transportation, Spatial Planning, Healthcare Facilities, Education, Emergency Services, Businesses, Shopping, Arts and Sports are covered in this paper.

2. Introduction

Automobile accidents claim 1.3 million *[1]* lives every year. An economy centered on automobiles causes waste of space, including but not limited to huge road infrastructure, parking lots/garages, gas stations, repair facilities and dealerships. Effects of the last 100+ years of automobile centric infrastructure cannot be reversed overnight; however, city planning for newer portions of existing cities or newer cities themselves can hugely benefit from the outline presented in this paper.

This paper proposes two basic building blocks of a city –

2.1. City Block

This is the primary residential space in a city. Basic necessities like primary schooling, regular shopping needs, medical and emergency facilities are provided within the City Block itself.

Following considerations are provided for a City Block

- Each City Block is 1km x 1km in size and is separated from other City Blocks by a distance of 1km [1].
- Trains are the only mode of transport across City Blocks except for emergency vehicles.
- At least 50% of the space is preserved as Open Space, which includes pathways, parks and public transport.
- Up to 30% space is earmarked as a residential space with building structures to have 6 or fewer stories (including the ground floor). The ground floor houses small businesses.
- Suggested maximum population per block is 30,000 people.

[1] An alternate design may separate two city blocks by a distance of 750m instead of 1km. Area of the Facility Corner, total land requirement and population density will change accordingly.
A more dense chess pattern is described in Appendix.

- The remaining 20% space in the City Block is reserved for shopping malls, primary schooling from Kindergarten to eight grades, libraries and religious institutions.
- It is suggested that each building in the City Block houses solar panels on its roof.

2.2. Facility Corner

A Facility Corner is spread as an Octagon with each side measuring 1km. With an overall space of 4.8 square kilometers, each Facility Corner performs a specific function as outlined below.

- Educational Institutions ⇒ High Schools, College and Post Graduate Institutions
- Businesses ⇒ Light Industry only
- Hospitals and Medical Colleges
- City Hall and Legal Facilities
- Sports complexes
- Arts Square ⇒ Theatres, museums etc.

Each Facility Corner will have buildings up to 5 stories tall (including the ground floor). 40% of the space is preserved as Open Space. Based on the need, Facility Corners will also have temporary accommodations, in the form of hotels, hostels and lodges, for visitors outside the city. Just like buildings in the City Block, each building in the Facility Corner will house solar panels on the roof.

The next section depicts a schematic outline of City Blocks and Facility Corners in a growing city.

3. A Growing City

Figures 1 through 6 show the natural growth pattern of a planned car-free city. The promise is to start small and grow big as required. The starting point is a 1km x 1km area dedicated as a City Block.

Figure 1: A City Block

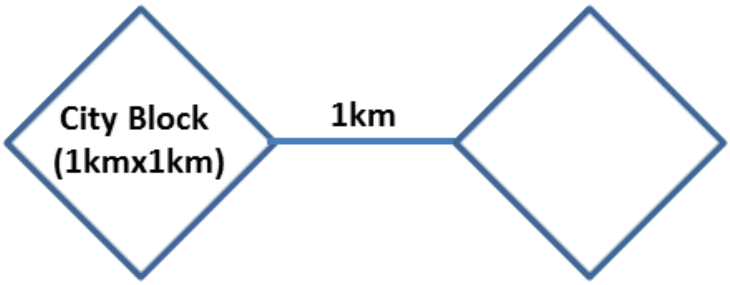

Figure 2: Two City Blocks

The following diagrams depict the suggested order of adding Facility Corners.

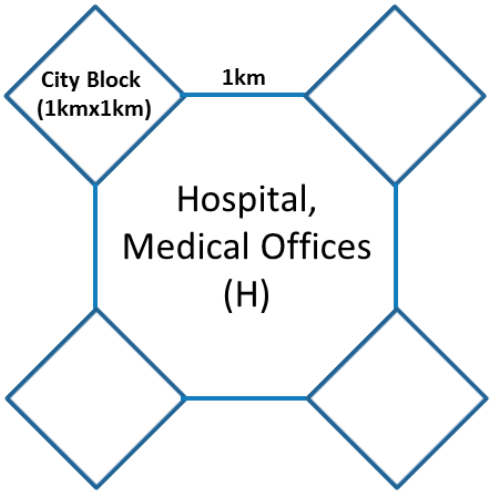

Figure 3: First Facility Corner

If a new city is being built in this fashion, the first Facility Corner will have Hospitals and Businesses together, however, as the city expands, city planners should include plans to move the businesses into their dedicated Facility Corner. Even when the city is as small as a single City Block (although not shown in the figures), a Facility Corner which includes Hospitals (and possibly a few businesses) needs to be planned.

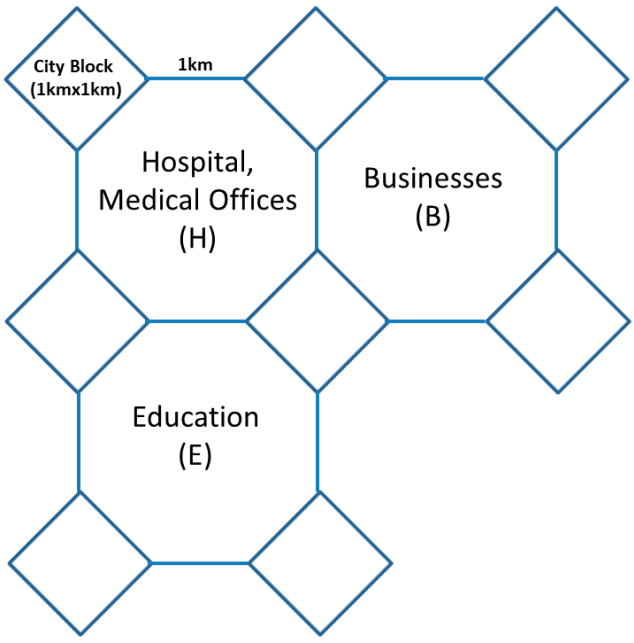

Figure 4: Population approaching 240,000

If an existing city is being expanded, the City Block may depend on services already provided in the city until at such a point in time that the city becomes self-sufficient with most of the facilities provided within the city.

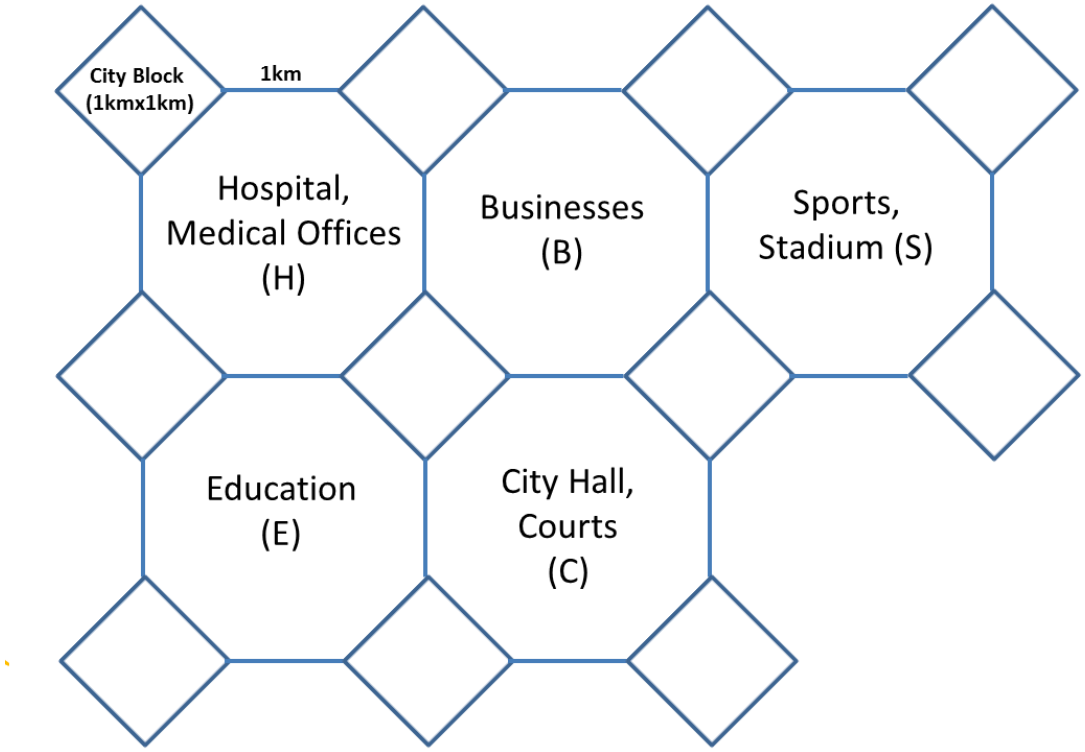

Figure 5: A self-sufficient city (Population 330,000)

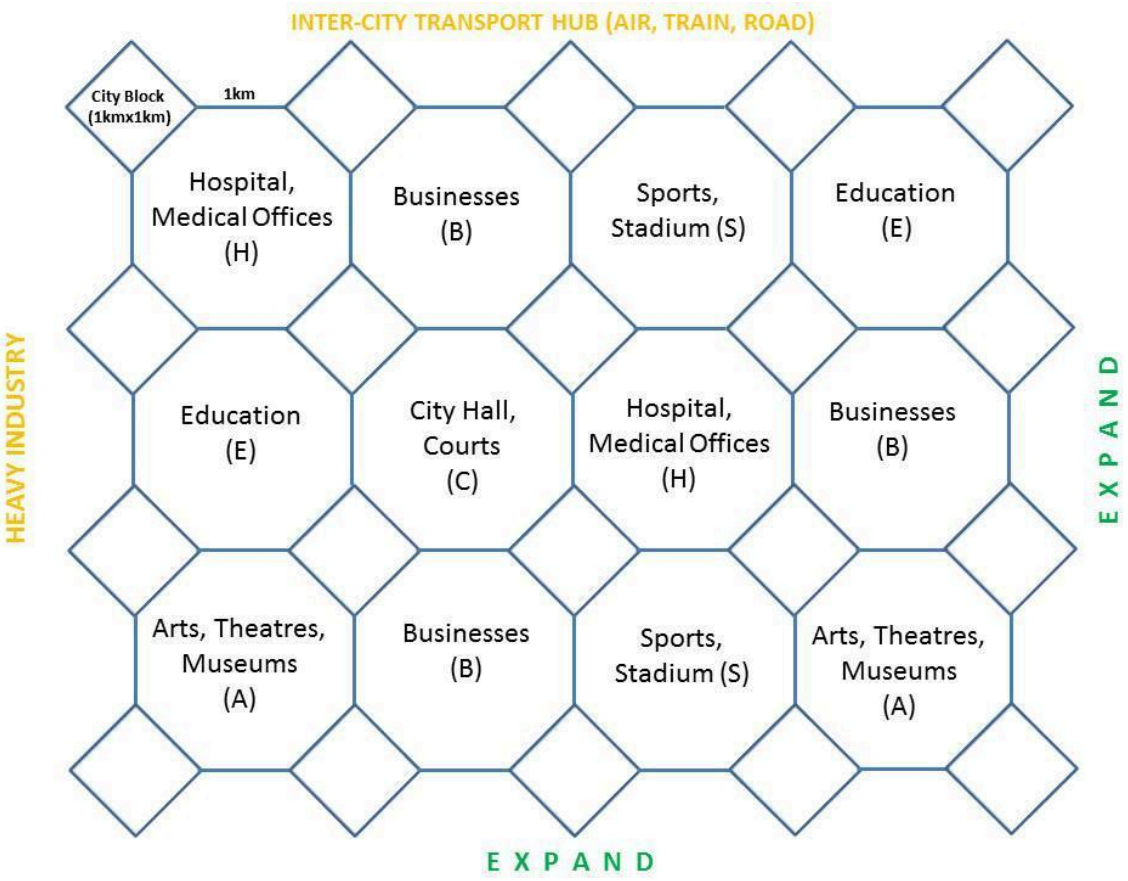

Figure 6: Mid-size city (Population 600,000)

Heavy Industry and inter-city transport (air, train and road), as shown in Figure 6 are distributed on two sides of the city, leaving the other two directions for the anticipated growth of the city.

The city, as shown, covers a land approximately 11km x 9km in size, effectively covering 99 square kilometers with a population density of 6,060 people per square kilometer. Table 1 below shows a comparison of World cities based on the population density.

City	Population	Land Area (km^2)	Population Density
New York *[2]*	8,550,405	775	11,030
San Francisco *[3]*	864,816	120	7,207
Proposed Car-free City	600,000	99	6,060
Greater London *[4]*	8,673,713	1,572	5,517
Washington DC *[6]*	672,228	156	4,310
Paris (Urban Area) *[7]*	10,870,000	2,845	3,700

Table 1: Population Density comparison

4. Anatomy of a City Block

City Block is the primary living space in the city. In a mid-size city as depicted, there will be one City Block allocated for low income housing. There may be one or more City Blocks catering to the people at the higher end of the income spectrum. A City Block is lined with rail lines, the primary transportation mechanism across City Blocks and Facility Corners. There will be a buffer of 50m (shown by dotted lines) from the edge of City Block, where no development is allowed. This space is reserved for the train tracks and other infrastructure, including the train stations at each corner of the City Block. This strategic location of the train stations in this way means no commuter needs to walk or bike more than 1km to catch a train. Trees will be planted in this buffer area, which will act as a sound barrier to curtail the noise from the trains.

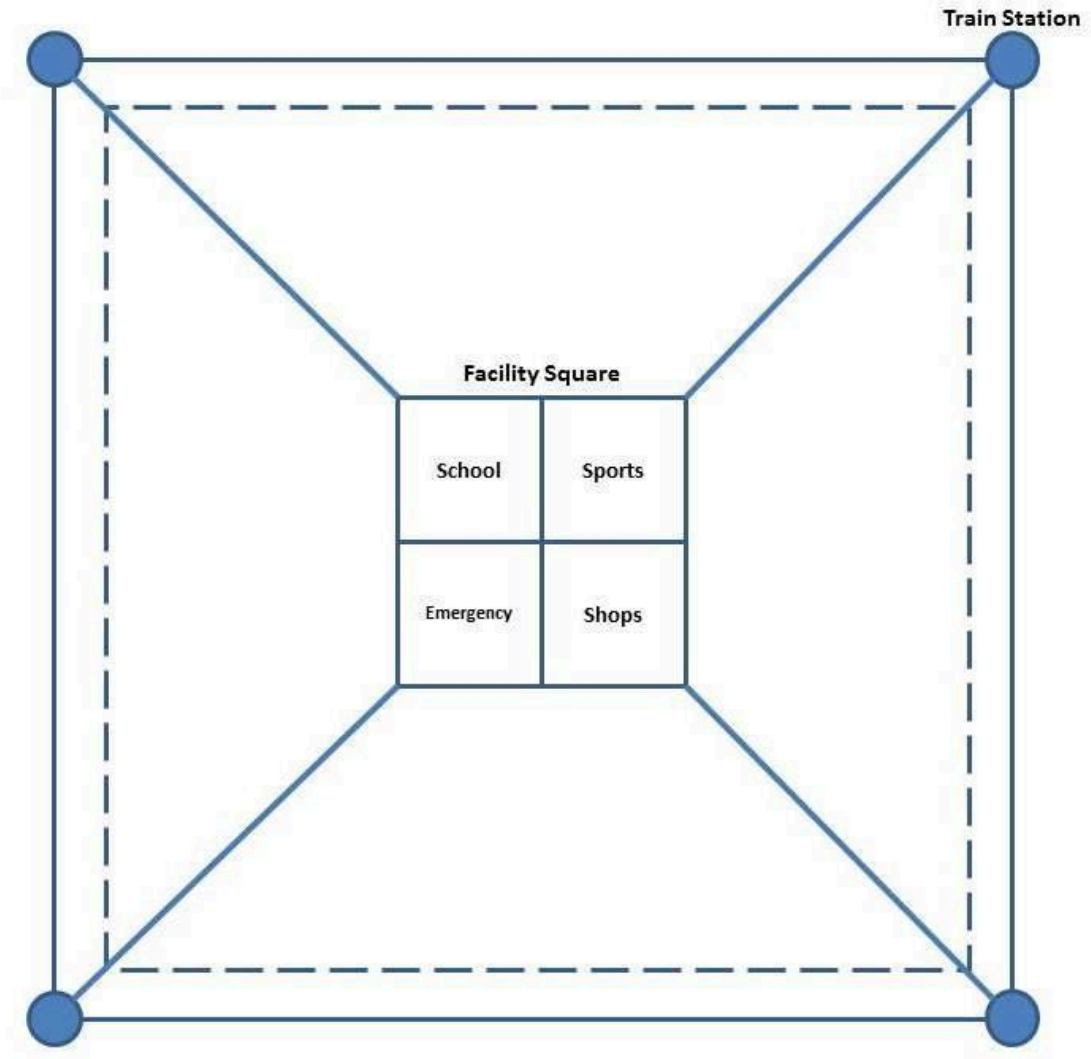

Figure 7: Anatomy of a City Block

4.1. Residential Space

Following calculations assume that 30% space in a City Block is used for housing, which amounts to 300,000 square meters. A City Block can accommodate up to **30,000** people. The suggested living space for each resident is 40 square meters. This amounts to a requirement of 1.2 million square meters living space per City Block. 5-story buildings (including ground floor for businesses), with the upper 4 floors dedicated for living space satisfy the requirement of the total living space in the City Block. The architecture and distribution of the buildings within the City Block is left to the City Planning Architect and the developer. Different City Blocks may have different architectures.

4.2. Facility Square

Apart from housing itself, a City Block includes an area called Facility Square. Some of the facilities are distributed within the City Block, whereas others are centralized in a Facility Square located in the middle portion of the City Block. As depicted in Figure 7, Facility Square is a 300m x 300m space housing the following facilities –

- Middle School (6-8) ⇒ Elementary grades (K-5) will be distributed within the City Block. Providing the Primary Schooling within the City Block itself means smaller kids don't have to take trains every day.
- Sports ⇒ A facility with a playground, jogging track and gymnasium will be offered.
- Shops and Banks ⇒ Facility Square will predominantly have banks, restaurants and specialty shops. Regular shopping needs will be distributed throughout the City Block.
- Emergency Services ⇒ Fire, Ambulance and Police

The Facility Square is connected to all the four train stations by paved roads. These connections will facilitate transportation of goods from the train stations and will also be used by emergency services. Only electric vehicles will be allowed on these roads.

5. Transportation

Transportation can be divided in three broad categories

1. Across City Blocks and Facility Corners (Inter-mode)
2. Within a City Block or Facility Corner (Intra-mode)
3. Inter-City Transport

5.1 Inter-mode transport

The city provides Inter-mode transportation using train services. While designing the train services, it is imperative to understand how many people commute using the Inter-mode transportation. Based on the age distribution statistics *[8]* , the overall population can be grouped in the categories below.

Age Group	Percentage	Need to Commute	Comments
0-13	19.8	No	Primary schooling is offered within the City Block
14-65	66.7	Yes	Given that City Block also houses schools and businesses, each individual in this age group need not take inter-mode transport. It is assumed that 50% of people in this age group need to commute daily across City Blocks.
66 and above	13.5	No	

Table 2: Age Distribution and Inter-mode Transport

Assumptions

- Based on Table 2, 33% of the population (or 200,000 people) in the city needs to commute daily. The city is spread over a land area of 11km x 9km. The maximum distance travelled by train on each train segment (East-West or North-South) will be 14km and 11km respectively. This means, if a person commutes from one end of the city to the exact opposite end, a distance of 25km will be covered. It is assumed that each commuter on an average covers half the distance or 12.5km one way or in other words, 25km within a day (back and forth).
- A train, with 3 coaches, will carry 300 passengers. One of the coaches is designated as first class, with a capacity of 60 people and the other two coaches are designated as second class, with a capacity of 120 people each.
- A train covers 30km in one hour, including all the stops. This means a train completes one segment (back and forth) in one hour. Upon completion of one round trip, the train carries 30 x 300 = 9000 passenger kilometers (pass-km)
- Commute time stretches 3.5 hours in the morning and 3.5 hours in the evening.

Calculations

1. The total commute per day in the city = 25km x 200,000 = 5,000,000 pass-km
2. Train segments = 9 (4 East-West and 5 North-South)
3. Each train segment needs to accommodate = 5,000,000/9 = 555,555 pass-km per day

4. Pass-km per commute-time hour on a train segment = 555,555/7 = ~ 80,000
5. Trains required to ply on each train segment per hour = 80,000/9,000 = 9
6. Number of trains (3 coaches each) required in the city = 81

The calculations show that on an average, each segment should run a train every 6 min during commute hours. Apart from the commute hours, the frequency can be reduced to once every 10 min during off-peak hours and every half an hour during the night time (11pm-5am).

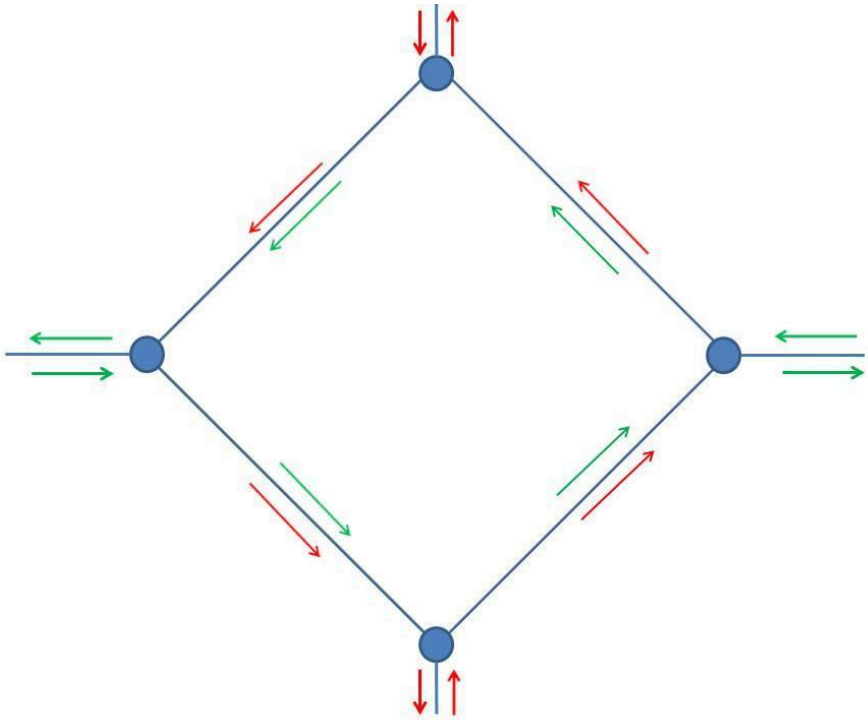

Figure 8: Train Routes (Entry and Exit)

Figure 8 depicts the Entry and Exit of the trains in East-West and North-South directions.

Since the city is providing the inter-mode transport, it can levy a monthly fee on all the people availing the services, specifically people in the age group which need the commute facility. Given that the service assumes two class categories, the people opting for First Class services will be charged a higher monthly fee.

5.2 Intra-mode transport

Any transport within the City Block or Facility Corner strictly uses bicycles or electric vehicles, with a top speed of 40km/hour. This includes emergency service transportation. The city may consider providing bicycles for use by residents.

Pathways within these areas should be designed in such a way that emergency services have access to all portions of the Block or Corner. Only emergency personnel may be able

to cross City Block or Facility Corner boundaries using their vehicles which may be transporting critical patients or enforcing laws.

5.3 Inter-City Transport

Inter-City Transport Hub will include a long distance train terminal, airport, car rental facilities and parking structures. While cars are not allowed within the city, they can be rented from the rental facilities located in the hub for traveling to other cities. Also the parking spots in the hub may be leased by city residents.

5.4 Goods transport

Inter-city Transport Hub will be the shipping and receiving locations for goods into and out of the city. These goods are transported into the city on flatbed cars using the same rail infrastructure used for passenger transportation; however, goods transport is strictly restricted to off-peak hours. Goods trains will run at a frequency of half an hour during these off-peak hours. The unloaded goods will be transported to relevant parts of City Blocks/Facility Corners using the intra-mode transport.

5.5 Refuse Collection

The landfill site will be outside the city; one possible location is alongside the Heavy Industry. Each City Block and Facility Corner will have trash and recycle collection bins for use by residents and businesses. Refuse will be collected on weekdays from all these bins by electrically operated vehicles and transported to the nearby train station on the path of the refuse train. Special refuse trains will ply between 2pm to 3pm which will carry the trash and recycle items collected in containers, one container per City Block/Facility Corner. Figure 9 shows refuse collection points (shown in orange) in a part of the city.

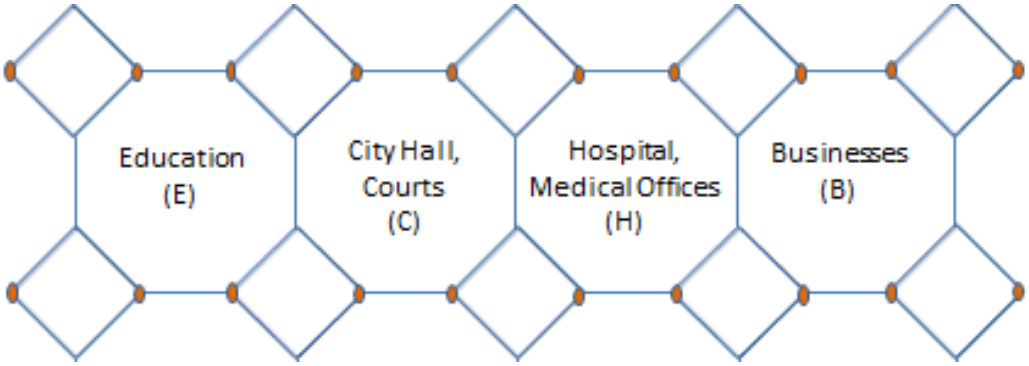

Figure 9: Refuse Collection Points

6. Summary

This paper outlines the plan for a city which defies the reliance on automobiles. Development of such a city will not only be **environmentally friendly** but will also elevate the **quality of life** for individuals as they don't have to drive daily and get stuck in traffic. Another big advantage is the **elimination** of car related injuries and **deaths**. Space is utilized better and plenty is available as **Open Space** for the betterment of life.

The paper also outlines a **step-by-step** approach, instead of a *rip and replace* or *build completely new* paradigm. This approach is thus amenable to most politicians and city planners.

7. References

Data retrieved from the following websites in August 2016, unless otherwise mentioned.

[1] Association for Safe International Road Travel
http://asirt.org/initiatives/informing-road-users/road-safety-facts/road-crash-statistics
Publisher – ASIRT
Data from July 2015

[2] New York City Population
https://www1.nyc.gov/site/planning/data-maps/nyc-population/population-facts.page
Publisher – New York City
Published in July 2015

[3] Quick Facts San Francisco County, California
http://www.census.gov/quickfacts/table/AGE115210/06075
Publisher - United States Census Bureau
Data (estimates) from July 2015

[4] London Datastore
http://data.london.gov.uk/dataset/land-area-and-population-density-ward-and-borough/resource/cc4e7e08-3071-488f-bdd9-a62cb1ed1c5c#
Publisher – Greater London Authority
Published in September 2015

[5] Quick Facts New York City http://www.census.gov/quickfacts/table/AGE115210/3651000
Publisher - United States Census Bureau
Data (estimates) from July 2015

[6] Quick Facts District of Columbia http://www.census.gov/quickfacts/table/AGE115210/11
Publisher - United States Census Bureau
Data (estimates) from July 2015

[7] Demographia World Urban Areas http://www.demographia.com/db-worldua.pdf
Publisher – Demographia World Urban Areas
Published in April 2016

[8] United States Census Bureau http://www.census.gov/population/age/data/2012comp.html
Publisher - United States Census Bureau
Data (Population by Age & Sex) - 2012

Appendix

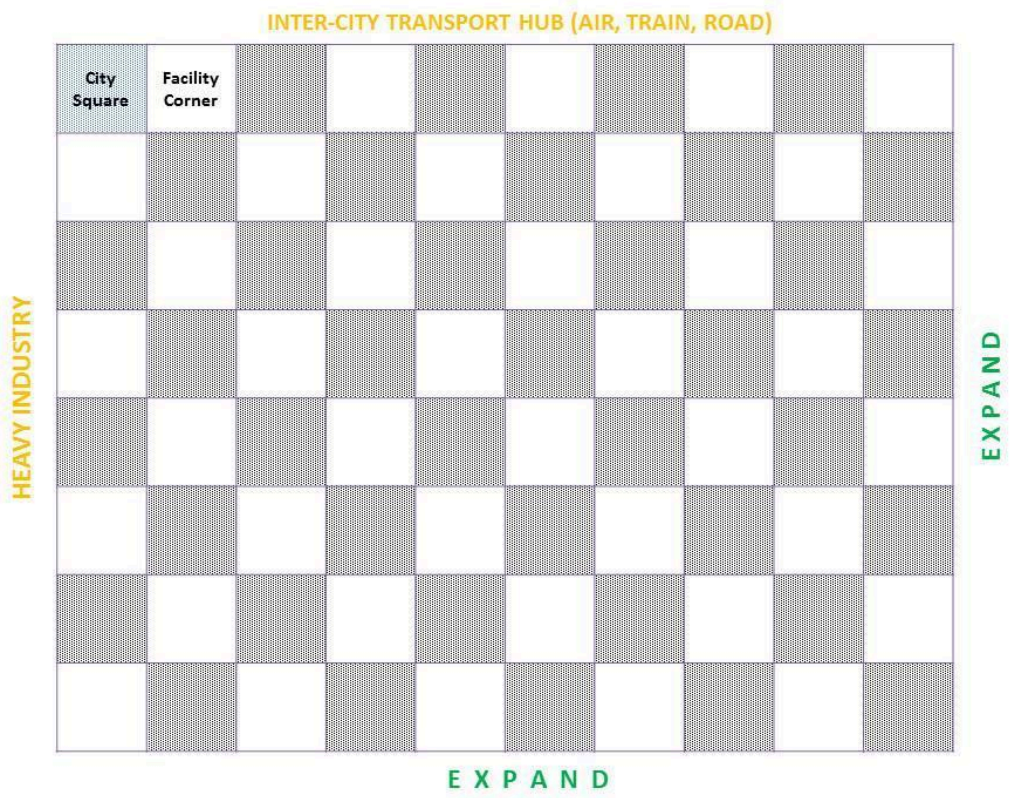

Figure 10: Chess Pattern

For cities which need a denser pattern than the one discussed in Figure 6, chess pattern, as shown in Figure 10, can be considered. This pattern positions City Square and Facility Corner in an alternating sequence. Each of these blocks is 1km x 1km in size. Thus the size of the city as depicted in Figure 10 is 10km x 8km, covering a land of 80 square km. Following guidelines are proposed for this city.

1. Each City Square can accommodate up to **25,000** people. This will help keep the city's population to facility corner area ratio in check. The city shown in Figure 10 will have a total population of **1,000,000** with a population density of **12,500** people/square km.
2. The city can be expanded by 2km x 2km area at a time, thus 2 City Squares and 2 Facility Corners will be added at a time.
3. The Facility Corner distribution in the city will cover
    a. **6** (Six) Corners housing Hospitals, Medical Offices and Medical Colleges
    b. **6** (Six) Corners housing Educational Institutions including High Schools and Colleges
    c. **6** (Six) Corners for Sport Complexes
    d. **6** (Six) Corners for Arts Squares
    e. **2** (Two) Corners for City Hall and Legal Facilities

f. **14** (Fourteen) Corners for Businesses (Light Industry)

4. The average train speed, including stops, will be 30km/hour. This means, a round trip on East-West track (total distance of 20km), will take 40 min and a round trip on North-South track will take around 30 min.
5. Below calculations use the same assumptions as in section 5.1 (unless noted otherwise)
    - Number of people taking inter-mode transport = 333,333 (1/3rd of the City population)
    - Average commute per person = 9km (Half of East-West & North-South distances)
    - Total passenger-km per day = 333,333*9*2 = 6,000,000 (Morning & Evening combined)
    - Total commute hours = 6 (adjusted down)
    - Passenger-km per hour = 1,000,000
    - Total train segments (9 East-West, 11 North-South) = 20
    - Total track length = 178km
    - Passenger-km per hour per segment (1,000,000/20) = 50,000
    - Passenger-km per hour per train = 6,000 (Each train capacity is adjusted down to 200)
    - Number of trains per track (50,000/6,000) = 9
    - Train frequency = Every **6-7** min
6. City expansion will keep population density unaltered. For example, a 20kmx16km city, covering an area of 320 square km will accommodate **4,000,000** residents, while the population density will be maintained at **12,500** people/square km.
7. Other aspects of the city, including intra-mode transport, inter-city transport, goods transport and refuse collection will remain the same as depicted in section 5. City block anatomy also remains the same as previously described.