TEHRAN LONG TERM URBAN RAIL PLAN

Introduction
Greater Tehran is currently one of the most populated mega cities in the world with an estimated population of 14 million inhabitants and 13 million daily motorized trips. Improving the Public Transportation has become crucial in Tehran when the increasing road congestion jeopardizes air quality as well as economy profitability of the city workforce.

Due to the important changes in the population, vehicle supply, the great modifications of the land use, and new urban development and also opening of 4 urban rail lines and the new road infrastructure implementation of Tehran since the last traffic studies in 1970's, it was essential to update the urban public transportation strategy development. The proposed transportation system of Tehran would have to meet not only the growing demand for transportation but also the urban development expansion of the city. In addition, the transportation system had to satisfy the inhabitants rising expectations for quality of life and preservation of the environment.

Objectives of the study
In mid-2005 TUSRC fixed the major objective for the “Tehran Rail Public Transport Long Term Development Study”: the achievement of an efficient urban rail network by the year 2030. The future urban rail network will have to fit with the spatial transportation demand according to the urban development perspectives. The integration of all needs and natural limitations will have to be taken into account while bearing in mind that the final recommended urban rail network will have to be realistic and affordable.

Methodology set up for the study
Tehran Long Term Urban Rail study is supported by a proved scientific and rational method adapted to Tehran specific characteristics; it comprises the main following issues:

- In-depth analysis of Tehran backgrounds which encompass urban and economic features, transport conditions and natural constraints.
Introduction and Methodology

- Identification of objectives and principles for Tehran Long Term urban rail plan.
- Recommendation of urban rail future levels of service.
- Sizing of Tehran Long Term Urban Rail Network, considering the previous issues in the context of Tehran future economic wealth.
- Concepts and principles for the design of urban rail networks.
- Agreement on a well proved multicriteria analysis specifically adapted to Tehran context to compare several urban rail network scenarios.
- Design process of several network scenarios supported by the whole previous issues.
- Recommendation of the scenario which fits the best with the objectives after the multicriteria analysis.
- Refinements and adjustments to finally propose Tehran long term urban rail Plan.

An in-depth study of Tehran current situations is crucial to understand the organization and functioning of a city. The consideration of the long term trends is even more essential to define the most suitable objectives for Tehran future long term urban transport. 3 main issues, which are the sound bases of a city functioning, are examined: Urban development, Transport development and Economic development.

The key findings regarding Tehran background encompass the following issues:

Tehran Background

Tehran urban development

Tehran Municipality is presently organized according to a monocentric urban organization. It can be summarized by the existence of a major CBD (districts 6, 7, 11 and 12) which concentrates the commercial activities, surrounded by several residential areas.

The general conclusions of the future trends in terms of population distribution are a higher development of the northern and eastern part of Tehran Municipality and a lower development for the south of the city and the districts 21 and 22.

Nevertheless, the proposals regarding Tehran future Master Plan especially highlight the need of urban activities concentration in specific areas, already existing or planned to be developed. These proposals are taken into consideration as urban centers to serve with the future urban rail network. The planned population of Tehran Municipality is around 9 million inhabitants in 2030.
The already existing polycentric urban development of Greater Tehran is planned to be reinforced in the future; keeping an unbalanced east/west population distribution with Karaj and Islamshahr as the 2 most populated areas. This urban development is taken into account for Tehran future urban rail network design, with the satellite cities related to Tehran Municipality core, as indicated beside. Total population of Greater Tehran is estimated to reach up to 19 million inhabitants in 2030. Thus, 6 corridors of development are taken into consideration to be potentially linked to Tehran through 6 gateways.

Existing national railway facilities could be re-used for the establishment of the suburban part of the future urban rail.

One of the objectives of the future urban rail network will be to serve the outer of Tehran. Public transport hubs such as the 4 existing intercity bus terminals, Mehrabad airport and Shoosh main Railway Station are identified.
They are mainly located in Greater Tehran where the link to Imam Khomeyni International Airport is obviously taken into account. Finally, Tehran main highways gateways are identified to possibly develop Park & Ride facilities in order to limit the car use by transferring the trips to the urban rail.

Tehran future transport demand

The currently daily motorized trips are estimated to around 13 Millions; by the year 2030, around 19 million of motorized trips are expected daily, including trips coming from the satellite cities, which represent nearly a 60% growth in 25 years. To cope with the growing motorized trip demand will require adequate measures to orientate the demand towards the public modes if considering the car ownership growth trends.

Current and future modal share

The modal share of public transport is thus expected to be 45% of the volume of motorized trips. This represents a great change with respect to current modal share, where public transport hardly represents 1/4 of the total motorized trips. 19 million motorized trips are estimated in 2030, of which 45% would be accommodated by public modes.
It is essential to consider the future trends in the transportation demand, in order to propose the most appropriate combination of urban rail lines that fit the demand structure and optimize the travel time of Tehran inhabitants. The desire lines structure come from traffic forecasts of TCTTS and provide a skeleton which represent a sound basis for the future urban rail network structure inside Tehran. In addition are also considered the movements related to the satellite cities showing their respective importance.

The investment capacities for urban rail transport projects are estimated as a proportion of the GDP. International Association of Public Transport indicates that around 0.5% of city's GDP is dedicated to public transport investments in Europe, on average; up to 1.2% when urban rail projects are in the preliminary stage of implementation.

For Tehran case, 2 development steps are thus considered: an investment rate of 1.2% of Tehran GDP, when there is a huge need of urban rail development till 2016; then a rate of 0.75% of Tehran GDP to enable continuing the urban rail implementation. Growth assumptions are taken for Tehran GDP, in a range of 3% to 6% up to 2030 AH. Tehran potential urban rail investments are thus assessed between 11 Billion US$ to 15 Billion US$. On this basis, a preliminary sizing of the urban rail network indicates a range from 200km to 350km of new urban rail lines.
The examination of the former Public Transport studies appears to be of greater importance in the analysis of Tehran transportation context to enlighten the design of the future urban rail network. An in-depth review of 5 major studies highlights the advantages and restrictions of the proposed networks, which considered different systems and corridors. These studies are considered when designing the future urban rail network.

Finally, other issues to take into consideration are the natural environment constraints such as the specific topography and geology of Tehran, the seismic conditions.

Objectives and principles to guide the urban rail network design
Tehran major transport stakeholders and authorities where identified directly concerned by Tehran long term urban rail network. Objectives and principles regarding the functions and role of the future urban rail lines were associated to each transport party. The most important principles are certainly the levels of services which have to be carefully chosen, adapted to Tehran, in order to help the designing of an efficient and attractive urban rail network:

- To be the heart of the Public Transportation
- To be in a position to compete with the private modes.

Two important levels of services are chosen, which are essential for the sizing of the future urban network and the structure of the network:

- The accessibility to the network which is measured by the walking distance to access to the stations.
- The accessibility to the urban activities which is measured by the trip duration on the rail network.

These 2 levels of services are obviously interrelated. Indeed, the walking distance directly impacts on the network station spacing and therefore on the commercial speed and the trip duration. The following levels of services are proposed as targets for the long term. They reflect the preponderance that should have the urban rail network in Tehran urban life.

### Walking distance and city urban coverage

On one hand, the walking distance to the stations should be attractive for the passengers and therefore should be minimized. On the other hand, too many stations would tend to reduce the commercial speed and therefore to limit the competitiveness with the private modes. So an adequate compromise has to be considered.

In the long term, it is proposed that all the inhabitants of the dense areas of Tehran Municipality should access to an urban rail station within a radius of less than 800m from their home or job, except in the car restricted area, where it is proposed a better supply and to limit the walking distance to less than 600m.

### Trip duration on the urban rail network

Trip duration represents an important issue for the inhabitants to reach easily and quickly the urban activities, making the network attractive or not. To be in a position to compete with the private modes, the trip duration is proposed to be less than to 45 minutes to reach Tehran CBD and between 60 to 80 minutes to go through Tehran Municipality.

Due to the wide Tehran area expanse, these targets lead to recommend two levels of services:

- One which will supply an average commercial speed of around 50 to 60kph. This will induce a station spacing of about 2,500 to 3,000m.
- One which will supply a more standard average commercial speed of around 30 to 40kph. This corresponds to a station spacing of around 1,000 to 1,500m.
The levels of service previously determined lead to propose a hierarchy between the transport functions, which have to be interrelated:

1. Express level: Supplying a 50-60kph commercial speed, this level can serve both Tehran Municipality and Greater Tehran. This service will be based essentially on fast access to the main urban activities and will serve in particular all the national and international hubs.

2. Urban level: Supplying a more standard 40-40kph, this level will serve mainly the dense areas of Tehran Municipality; it will be based on high level of supply (headways, capacity) and will be integrated with express level through interchanges.

The concept of urban rail network design is built on complementary and integrated services, as presented beside.

In addition, a third level is assumed to answer more local transport needs and to feed the 2 other levels of service.
Public transport connectivity is defined as the ability to provide service to a maximum of trips through the optimal integration of lines, schedules, fare and information systems and modal transport facilities.

As far as Tehran long term urban rail network is concerned, a double objective guides the design in order to optimize the network connectivity:

1. To promote a good support to the urban development by offering several options to the passengers in a specific urban area, especially the existing and planned urban centers and facilitate their trips.

2. To facilitate the passenger transfers by well planned transport integration in order to increase the attractiveness of the urban rail but also more generally to increase the attractiveness of the Public Transport. In that case, transport connectivity integrates in a same place the different levels of services of the urban rail itself, but also when appropriate, the other public transport modes and the private modes.

Definitions are mentioned hereafter:

- **TS**: Urban Rail Transfer Station
- **MIS**: Urban Rail Main Interchange Station
- **TH**: Transport Hub; it connects Bus terminals, Airports, Railways Stations or/and Park & Ride facilities

Several types of urban rail systems answer to Tehran specific needs in terms of urban rail systems. The diagram beside summarizes the commonly used classification, based on capacity, commercial speed and segregation of the right-of-way from the surface modes.

Considering the size and the density of the city and the relations with Greater Tehran in the future, MRT systems are recommended, because they are already implemented. The aim is to standardize the rail systems to optimize costs.
LRT could be chosen if the demand appears to be low. Monorail systems which are generally
dedicated to specific services could be chosen to serve Tehran Exhibition centre for example. Tram
or BRT systems would complement the MRT systems when the ridership is lighter, if the surface
implementation is feasible.

Revisions and new proposals were submitted after additional site visits which provided new
guidelines for the scenarios design. Finally, from the 11 draft scenarios, 4 network scenarios were
selected on the basis of a simplified multicriteria comparison.

The 4 network scenarios were refined, detailed and then tested through the multicriteria analysis
presented hereafter and with the help of TCTTS traffic forecast model. The objective is to select
the one which fits the best with the previous fixed objectives.
A multicriteria analysis allows the comparison of the 4 network scenarios in order to recommend the most appropriate long term urban rail network for Tehran. The advantages of such a method are to:

- Enable a wide range of criteria and indicators at the same time.
- Underline some major criteria by giving them a more important weight.
- Easily calculate the utility function as a linear combination of the defined indicators.

The multicriteria analysis offers the possibility of ranking the network scenarios in maximizing the utility function. Criteria and indicators generally reflect the different points of view of every transportation party through their related areas of relevance and associated objectives. This type of multicriteria assessment, which was already proved in other foreign cities cases such as Budapest, Beijing, Shanghai or Dubai, was specifically adapted to Tehran objectives.

**Weighting system selected for Tehran**

The aim of a criteria weighting system is to assess the robustness of the network scenarios when they are confronted to contrasted transport planning policies. Generally several weighting options attach more or less importance to some of the objectives which support the future urban rail network. Several options were proposed to finally select the two following options, agreed during the 2005, October seminar.
It should be stressed that the network scenario ranking is similar in both of the two weighting options and network scenario 4 gets the best ranking. Presented below is the ranking from the best notation to the lowest:

1. Network scenario 4
2. Network scenario 2
3. Network scenario 1
4. Network scenario 3
Some adjustments and complements are then proposed to refine the network scenario 4 design, based on several discussions and meetings with TUSRC, TCTTS, BOOM SAAZ GAAN, Tehran Urban Development Institute, TGIC and other transport and urban planning stakeholders. The objective is to:

1. Improve the urban city coverage: adjustments of lines n°8 & n°7 are proposed as well as development of complementary tram/BRT services
2. Reinforce the connectivity: adjustments of lines n°6, n°9 and Express lines II, III & IV are proposed,
3. Strengthen the urban integration: adjustments to line n°9 are proposed,
4. Fill a gap of services: additional monorail service is proposed, dedicated to Tehran Exhibition center

After integrating these modifications, the recommended network scenario 4 is named “Tehran Long Term Urban Rail Network”.

Tehran Long Term Urban Rail Network has a total length of 430km, of which more than 300km are new alignments; it will serve 276 stations inside Tehran. The network has a balanced distribution of 4 Express lines and 8 Urban lines between the east and the west of the city, including the existing and committed lines n°1 to n°5. All the lines are organized in complementary services through 54 transfer and 13 main interchange stations, which provide an excellent connectivity to Tehran other transport modes and to Tehran outer gateways. The connectivity is strengthened by the existence of Express lines I and II crossing the city and by the loop around the CBD formed by the Express lines III and IV.

5 Tram/BRT lines of around 60km are also sketched to perfect and feed Tehran urban rail lines; they are assumed to supply a more local service. At last, a dedicated monorail line is also outlined to serve Tehran Exhibition center.

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