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Developing Innovative Concepts for Measuring and Assessing Transit System Maturity

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Abstract

In this research three new innovative concepts are introduced and developed: the first defined as Transit System Maturity Components (TSMC), the second referred to as Transit System Maturity Scale (TSMS) and the third labeled as Transit System Maturity Index (TSMI). The TSMC is meant to conceptualise the main strategic generic components characterising the maturity of transit systems. The TSMS is an S shaped scaling system for measuring maturity of transit system components. The TSMI presents an innovative index meant to assess the overall level of maturity of a city transit system. Such framework is envisaged to be used to determine and compare the overall maturity levels of transit systems in cities of the world as well as to act as a basis to identify strengths & gaps that need to be addressed/completed. Furthermore, it can also act as an ingredient in shaping and developing future road maps for transit system in cities across the world. The research concludes by demonstrating the applicability of TSMC, TSMS, and TSMI in conducting an initial assessment of the Transit System Maturity for the fast growing city of Dubai.

Keywords

Transit, Maturity, Components, Scale, Index

1. Introduction

Limited research addressed the concept of maturity of transport/transit/mobility systems in cities across the world. One relatively recent study was conducted by [1] and reported an Urban Mobility Index that included 5 mobility maturity criteria and 6 mobility performance indicators. Based on this around 84 cities were assessed and ranked. However, the research reported in this paper introduces three novel concepts to assess transit maturity in cities across the world. The three innovative concepts include the concept of Transit System Maturity Com-

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ponents (TSMC), the concept of Transit System Maturity Scale (TSMS) and the concept of Transit System Maturity Index (TSMI).

The TSMC is meant to conceptualise the main strategic generic components characterising the maturity of a transit system. Such components are classified in this research into 5 classes, 3 visible within transit organisations namely the hardware, the human-ware, the technology and software, and the other 2 are visible from the customer/city perspective, namely referred to as customer-ware and community/city ware.

The second concept known as TSMS is a scaling system for measuring maturity of transit system components. The TSMS is proposed in this research to follow the S shaped curve with 6 scaling levels including: 0) None, 1) Start Serious Consideration (Infancy), 2) Plan & Implement (Initiation), 3) Operate & Grow (Growth/Partial Maturity), 4) Efficient & Optimum (Mature), 5) Leading & Advancing (Beyond Maturity).

The third concept referred to as TSMI represents a mathematical model for the computation of the weighted scoring of each component characterising the transit system and hence it generates the overall assessment of the maturity level of the transit system.

Such framework is envisaged to be utilised to determine and compare the overall maturity levels of transit systems in cities of the world as well as to act as a basis to identify strengths & gaps that need to be addressed/completed. It can be used for assessment and comparative purposes both for self-city comparisons across time as well as for cross-sectional city to city comparison. It is also expected to assist in compiling priorities and areas of focus that can shape future road maps for transit systems across the world.

Furthermore, the research demonstrates the strength and applicability of TSMC, TSMS and TSMI in conducting an initial overall assessment of the Transit System Maturity for the fast growing city of Dubai. It has to be noted that such assessment is by no means comprehensive and merely serves for demonstration purposes.

2. Objectives

The main objectives of this research are as follows:

Develop and introduce to the transit literature three innovative concepts the first known as Transit System Maturity Components, the second known as Transit System Maturity Scale (TSMS) and the third referred to as Transit System Maturity Index (TSMI).

Demonstrate the applicability of the above 3 concepts by conducting an initial assessment of the maturity of transit system in Dubai.

3. Methodology

The following presents the main steps constituting the methodology adopted in this research.

Provide a conceptualisation of the main strategic generic components charac-

terising the maturity of a transit system.

Identify and discuss key generic criteria that can be used for assessing the maturity of transit systems in cities across the world.

Develop a maturity scaling system for measuring the maturity of transit system components—This will follow the S shaped curve with 5 scaling levels ranging from Infancy to beyond maturity.

Develop an innovative index that is meant to assess the level of maturity of a city transit system known as the Transit System Maturity Index (TSMI).

Demonstrate the strength and applicability of TSMI by applying it to conduct an initial assessment to measure the Transit System Maturity for the city of Dubai.

4. Transit System Maturity Components

This research adopts the view that transit systems should assist communities and cities in attaining sustainable development and reaching growth by ensuring adequate and smart planning, design, funding, provision, management, operation and maintenance of all necessary and required forms of transit supply (infrastructure, modes, facilities). This is meant to meet the expected transit passenger demand with acceptable levels of services for accessibility and mobility provision. This should be done in an integrated, economic, efficient, equitable, safe and secure manner taking into consideration minimising disruption to the environment/ ecology, reducing energy consumption and hence attaining what is known as a sustainable transit system.

As stated earlier the first innovative concept introduced in this research is defined as Transit System Maturity Components (TSMC). This is meant to conceptualise the main strategic generic components shaping and characterising a transit system. Such conceptualisation was based on the authors experience as well as on a number of literature reviews including [2]-[7]. Components proposed in this research are classified into 5 classes namely: the hardware, the human-ware, the technology and software, the customer-ware and finally the community/city ware, see **Figure 1**. These 5 classes are described as follows:

Class 1: Hardware—This includes all forms of transit infrastructure such as road and rail networks, depots, stations, stops, shelters dedicated lanes, BRT lanes. It also includes the transit fleet such as the metro, Bus Rapid Transit buses, Buses with High Level Services, Urban and intercity buses, marine fleet, taxis, limousine and other mobility modes including carsharing, ridesharing and e-hail such as Uber and Careem and the like. The hardware also includes all hardware components utilised as part of Intelligent Transit Systems applications.

Class 2: Humanware—This includes all forms of organisation structure, processes, management & human resources as well as the exercise of generic required activities of planning, operation, maintenance, regulation & governance.

Class 3: Technology & Software—This includes all the technology and software applied in Intelligent Transit Systems applications. It also includes all the management tools such as databases, Management Information Systems, Deci-

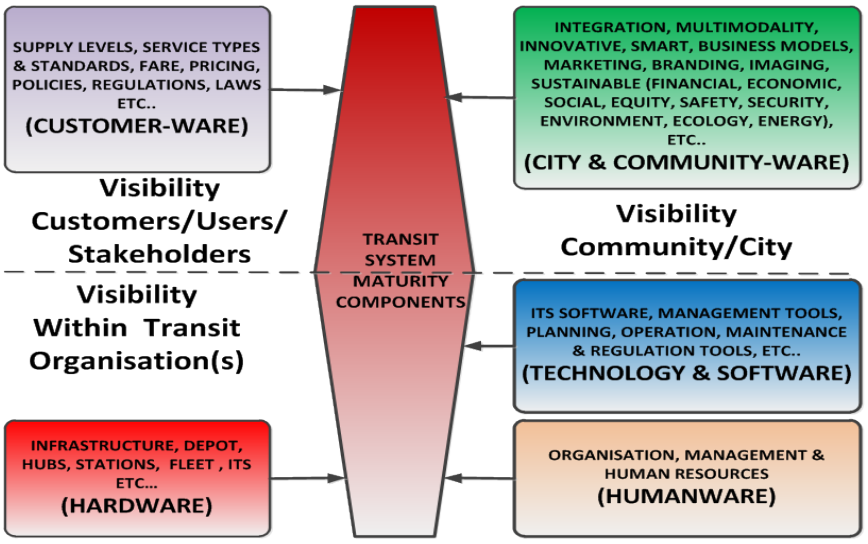

Figure 1. Transit system maturity components.

sion Support Systems, as well as the transit planning tools such as strategic transit planning software and models. This also involves other infrastructure and fleet maintenance tools and software as well as regulatory software and tools.

Class 4: Customer-Ware—The customer ware represents the customer perspectives and it includes what the customer perceives in terms of supply levels, service types, levels and standards as well as the transit fares, the pricing structure and the transit related policies, regulations and laws.

Class 5: Community/City Ware—This involves those components that are perceived by the whole city community and the outside world including the transit integration, multimodality, innovation, smartness, transit business models, transit marketing, branding and, imaging, as well as the transit system sustainability in terms of financial, economic, social, equity, safety, security, environment, ecology, and energy dimensions.

It should be noted that the hardware, human ware and the technology/software components are internal to the transit organisations and are mainly visible to the transit staff working in these organisations. On the other hand, the customer ware as well as the community/city ware are visible to the outside world external to the transit organisation both at the city and passenger/users levels. The above 5 classes are detailed in Figure 2.

5. Transit System Maturity Scale

The second concept known as TSMS is a scaling system for measuring maturity of transit system components. The introduced scaling system is suggested to follow the S shaped curve. S shaped curves are generically used to explain the development and growth of many phenomenons against time. In this research the TSMS starts with a transit infancy stage to a slow growth transit system initiation stage followed by a rapid exponential growth stage of transit system and passing through partial maturity and achieving full transit system maturity then

tapering or leveling off where transit growth becomes slow or negligible. However, in this research the S shaped curve stages are extended to include a fifth stage labeled here as transit system leading and advancing beyond maturity, see Figure 3 with the 5 main scaling levels as follows:

1) Start Serious Consideration (Infancy)
2) Plan & Implement (Initiation)
3) Operate & Grow (Growth/Partial Maturity)
4) Efficient & Optimum (Full Maturity)
5) Leading & Advancing (Beyond Maturity)

In broad terms, this research adopts the view that Transit System Maturity means that the transit system is Multimodal, Integrated, Intelligent, Innovative, Smart, Satisfactory, Seamless & Sustainable as introduced in [8].

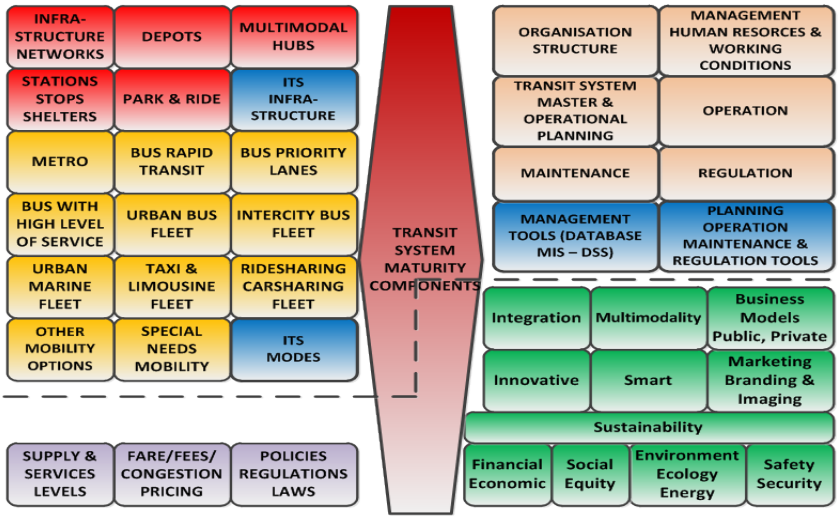

Figure 2. Details of transit system maturity components.

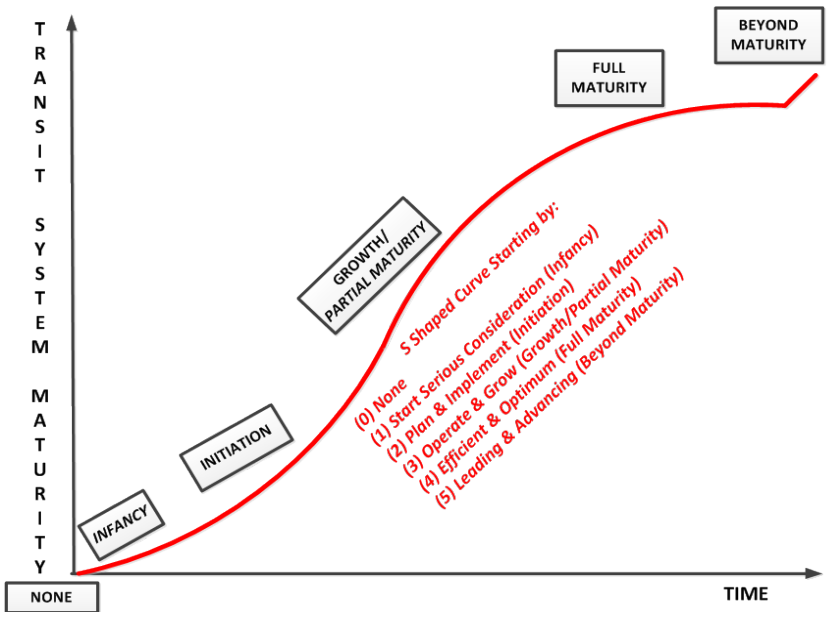

Figure 3. S shaped curve describing transit system maturity scaling levels.

6. Transit System Maturity Index

The third concept referred to as TSMI represents a mathematical model for the computation of the weighted scoring of each component characterising the transit system and hence it generates an index representing the overall assessment of the maturity level of the transit system. The following represents the TSMI Mathematical Model:

$$TSMI = \sum_{TSMC=1}^{n} Weight/100_{TSMC} * \left(\sum_{CATSMC=1}^{m} \left(TSMCScore_{(TSMC,CATSMC)} * Weight/100_{CATSMC} \right) \right)$$

In order to compute the TSMI for a particular city, 29 hardware, software and human ware inner transit organisation components are assessed where TSMC = 1,… n with n = 29. This assessment is conducted using 14 criteria representing the other customer ware and community/city ware components where CATSMC = 1,… m with m = 14. For each of the assessed components and the assessment criteria weights can be proposed via a Delphi expert exercise.

The above framework is envisaged to be utilized to determine the overall maturity levels of transit systems in cities of the world as well as a basis to identify strengths & gaps that need to be addressed/completed. It can be used for assessment and comparative purposes both for self-city comparisons across time as well as for cross-sectional city to city comparison. This is also expected to assist in compiling priorities and areas of focus that can shape future road maps for transit systems across the world.

7. Transit System Maturity Index: A Case Study of Dubai

Dubai is one of the fast growing cities in the world. The Roads and Transport Authority (RTA) is the concerned authority with all transit and mobility infrastructure and modes in the city of Dubai. RTA has made leap frog steps towards planning, providing and attaining a fully mature transit system. Still as in many other transit authorities there are many challenges to be overcome and steps to be taken. In addition to operating the Dubai red, green metro lines, the Dubai tram and a bus fleet of more than 1500 public buses operating over a network of 115 routes, see **Figure 4** extracted from [9].

Dubai is currently seriously considering the provision of more premium transit systems that represent critical components necessary for Dubai to complement its public transport system, namely the introduction of Bus Rapid Transit (BRT) System and the expansion of the current Bus Priority Lanes (BPL).

Additionally the e-mobility solution known as the Dubai Integrated Mobility Platform (DIMP) and the shared mobility options including Carsharing, Ridesharing and e-booking are currently in the implementation stages. Relying on the experience and knowledge of the author in his various international capacities and positions, the TSMS and TSMI were applied to measure and provide an initial assessment of Transit System Maturity for Dubai. This is detailed in **Table 1**.

Figure 4. Dubai integrated public transport network-source [9].

A weight was given to each of the 29 assessed hardware, software and humanware inner transit organisation components. Weights were also given to the 14 criteria used in the assessment and representing the customer ware and city/community ware components. The maturity level on a scale from 0 to 5 for each of the 29 assessed hardware, software and humanware is shown in Table 1 cells. Such levels were assessed for each of the 14 assessment criteria. A total of around 406 points of judgment are reported.

The overall maturity assessment was in the range of 2.9 as shown at the bottom of Table 1. This demonstrates that the city of Dubai is in the Operate & Grow Stage referred to as Growth & Partial Maturity. It is also expected that within the next 3 - 5 years, Dubai transit system, with all the current projects implemented and in full operation, to reach the full maturity level 4. Additionally it is expected that in some transit components Dubai can achieve the level 5 maturity *i.e.* Leading & Advancing beyond Maturity with projects such as the self-driving buses, the hyper-loop, the flying drones *etc.*

It has to be noted that such assessment is by no means comprehensive and merely serves for demonstration purposes. Further expert judgment can be applied to enrich the assessment via the Delphi expert approach similar to the assessment conducted and reported in [10].

8. Conclusions

This research developed and introduced to the transit research literature three novel and innovative concepts, namely the Transit System Maturity Components (TSMC), the Transit System Maturity Scale (TSMS) and the Transit System Maturity Index (TSMI). The TSMC is meant to conceptualise the main strategic generic components characterising the maturity of a transit system. The

Table 1. Application of TSMI to measure the Transit System Maturity for Dubai.

Criteria for Assessing Transit System Maturity Components (CATSMC) Transit System Maturity Components (TSMC)	Weight $_{TSMC}$	Supply Levels	Service Levels	Fare/Fees Congestion Pricing	Policies/Laws Regulations	Integration	Multimodality	Business Model	Innovative	Smart	Marketing/ Branding/Image	Sustainability				Weighted Sum
												Financial/ Economic	Social/ Equity	Environment Energy	Safety/ Security	
Weight$_{CATSMC}$		10	10	9	10	5	5	5	3	3	2	9	9	7	13	100
Infrastructure Networks	10	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3.6
Depots	3	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	2.7
Multimodal Hubs	3	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	2.7
Stations/Stops/ Shelters	3	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	2.7
Park & Ride	2	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	2.7
Metro	8	3	3	3	3	3	3	4	4	4	4	3	3	4	4	3.3
Bus Rapid Transit	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Bus Priority Lanes	4	2	2	0	2	2	2	2	2	2	2	2	2	2	2	1.8
Bus With High Level Of Service	4	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3.5
Urban Bus Fleet	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3.5
Intercity Bus Fleet	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3.5
Urban Marine Fleet	2	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3.0
Taxi Fleet	2	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3.5
Limousine Fleet	1	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3.5
Carsharing/Ridesharing	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
Other Mobility Options	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
Special Needs Mobility	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3.5
ITS Infrastructure	3	4	4	NA	4	4	4	4	4	4	4	4	4	4	4	3.6
ITS Modes	3	4	4	NA	4	4	4	4	4	4	4	4	4	4	4	3.6
Organisation Structure	4	3	3	NA	3	Not Appli.			4	4	4	4	4	4	4	2.9
Management, HR & Working Environment	8	3	3	NA	4	Not Appli. NA			4	4	4	4	4	4	4	2.8
Transit System Planning	6	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	2.7
Transit System Operation	5	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	3.2
Transit System Maintenance	3	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	3.2
Transit System Regulation	3	2	2	NA	2	Not Appli.			3	3	3	3	3	3	3	2.3
Management Tools	2	3	3	NA	3	Not Appli.			3	3	3	3	3	3	3	2.3
Planning/Operation/ Maintenance/Regulation Tools	7	3	3	NA	3	3	3	3	3	3	3	3	3	3	3	3.2
Weighted Sum = 2.9								100								

TSMS is a scaling system introduced for measuring maturity of transit system components. The TSMS is proposed to follow the S shaped curve with 5 main scaling levels. The third concept referred to as TSMI represents a mathematical model for the computation of the weighted scoring of each component characterising the transit system and hence it generates the overall assessment of the

maturity level of a transit system.

Such framework is developed to be utilized to determine the overall maturity levels of transit systems in cities of the world as well as to act as a basis to identify strengths & gaps that need to be addressed/completed. It can be used for assessment and comparative purposes both for self-city comparisons across time as well as for cross-sectional city to city comparison. It is also expected to assist in compiling priorities and areas of focus that can shape future road maps for transit systems across the world. The research demonstrated the strength and applicability of TSMC, TSMS and TSMI in conducting an initial overall assessment of the Transit System Maturity for the fast growing city of Dubai. The results showed that the transit system in Dubai can be assessed as being within the growth and partial maturity stage. It has to be noted that such assessment is by no means comprehensive and merely serves for demonstration purposes.

It is also expected that within the next 3 - 5 years that Dubai transit system, with all the current projects implemented and in full operation, to reach the full maturity level 4. Additionally it is expected that in some transit components Dubai can achieve the beyond maturity level *i.e.* Leading & Advancing.

Future research will look into comparing the maturity levels in several cities and identifying key success factors and drawing up generic road map for transit systems in cities of the world to be pursued for attaining desired transit system maturity levels.

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