Planning and Implementing TOD with the 3V approach MODULE 1: METHODOLOGY

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2nd Transit-oriented Development (TOD) Technical Deep Dive (TDD) Planning and Implementing TOD at City, Corridor and Station Scale Tokyo Development Learning Center

Planning with the 3V Approach at City Scale

Objectives

- Understanding the link between the 3V Approach and Land Value Capture
- Understanding 3V Approach Methodologies and Metrics
- Understanding how to calculate the metrics
- Understanding the policy levers to increase values

The land Value Capture Positive Feedback Loop



New transit infrastructure or planning decisions (such as rezoning at higher values or investing in the public realm) increase land value around transit stations. Capture of this value can create a positive feedback loop for financing infrastructure, enhancing the public realm, and supporting inclusionary housing.

The unlocking of an increase in the potential value of underused assets (land and/or structures) as a result of a public-sector intervention (rezoning or provision of transit infrastructure) stimulates demand from the private sector. Subsequent investment and development from the private sector ensure that potential asset value increase is realized.

Source: Huxley 2009. © ULI.



The node place model distinguishes five types of situations based on a station's node and place value **Balance:** Both node and place are strong. Transportation

infrastructure and local land use support each other, maximizing market value.

Stress: The intensity and diversity of infrastructure and land use come close to the maximum.

Dependence: There is no competition for free space, and demand for infrastructure is low. Both node and place values are relatively weak; factors other than node-place dynamics (for example, subsidization) must intervene for the area to sustain itself.

Unbalanced node: The supply of infrastructure is stronger than land use. There is potential of development in enhancing place value to leverage on the relative oversupply of connecting infrastructure. An example is King's Cross, where the combination of the HSR in Saint-Pancras and the national lines in King's Cross, with 6 subway lines and 17 bus lines creates the most connected European hub across many geographical scales from local to Europe.

Unbalanced place: The intensity of land use exceeds the supply of infrastructure. Local development potential should be encouraged by providing supportive infrastructure that increases connectivity.





Source: © King's Cross Central Limited Partnership (left) and © Françoise Labbé (right).



Although station areas along the Yamanote line in Tokyo, may be considered under stress and at maximum development, peaks of connectivity and land use intensity tend to continue growing, as experienced in Shibuya where real estate is still booming and new lines are added.

Source: Tokyu Corp.

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What are Node/Place/Market Potential values ?

Node Value





• Place Value

Market Potential Value

Sources: © King's Cross Central Limited Partnership (top); © Related Oxford (middel); Renne 2014 (bottom).



Node value describes the importance of a station in the public transit network based on its centrality (measured by graph theory centrality indexes), passenger traffic volume, and inter-modality

Place value describes the urban quality of a place and its attractiveness in terms of amenities, schools, and health care; the type of urban development; local accessibility to daily needs by walking and cycling; the quality of the urban fabric around the station, in particular its pedestrian accessibility, the small sizing of urban blocks, and the fine mesh of connected streets that create vibrant neighborhoods; and the mixed pattern of land use.

Market potential value refers to the unrealized market value of station areas. It is measured through a comparison between demand and supply, that includes *major drivers of demand* including current and future human densities (residential plus employment); and *major drivers of supply*, including developable land, potential changes in zoning (such as increasing floor area ratios (FARs)), and market vibrancy.

The 3 V Approach and the Land Value Capture Feedback Loop

Place Value

Increasing the urban quality and attractiveness of a location





Node Value

Increasing the connectivity and accessibility of a location by investing in transit





Market Potential Value

Increasing market demand and supply



The 3V dynamics at city scale





Place



Crossrail in London

Paddington

Bond Street

Tottenham Court Road Liverpool Street

Whitechapel

What are Node/Place/Market Potential values along a corridor ?

Node Value



• Place Value



Market
 Potential Value

Crossrail in London



The 3 V Approach and the Land Value Capture Feedback Loop along a corridor: London Crossrail



Place Value

Increasing the urban quality and attractiveness of a location



> Market Potential Value Increasing market demand and supply



Node Value

Increasing the connectivity and accessibility of a location by investing in transit







The Corridor Approach

For a successful integration of land-use and railway transport, a consistent network focus over a long period of time is needed. The approach needs not only focus on the integration of land-use and transport on a local station level but also on how to coordinate mobility and land use patterns on a higher level such as the corridor or even network level. There are several reasons why a corridor approach is most desirable. Within a railway corridor origin and destination locations can be developed in a coherent way. Coordination of the development of different station areas on a railway corridor reduces competition between different station areas on the same corridor and can even stimulate synergies. Furthermore, a corridor approach allows for developments to be coordinated in such a way that that the railway infrastructure is used more efficiently by creating a bidirectional traffic flow and generating off-peak travel. Railway corridors can operate on different levels, the lowest level being local, then regional, national and at the highest level international. For studying the context of railway development in Tokyo the regional level would be most suitable. This is mainly due to the fact that Tokyo's railway companies operate within their own region focusing on developing their own network and striving to use their own infrastructure as efficiently as possible.



Den-En Toshi corridor is a good example of the application of TOD. It is one of the longest running TOD projects that has been executed on a corridor level. Both the initial development of the corridor and the continuous redevelopment of the existing urban environment in and around station areas are meant to utilize the available space and infrastructure as efficiently as possible. Corporate strategy of the Tokyu Corporation has proved to be highly effective when looking at passenger numbers and company profits.

Today the Tokyu Den-En Toshi line has a length of 31.5 kilometers and a total of 27 stations, originating in the major hub of Shibuya via other major stations of Sangen-Jaya, Futako-Tamagawa, Mizonokuchi, Tama Plaza, Aobadai, Nagatsuta and terminating in Chūō-Rinkan.

The 3V dynamics at station area scale

King's Cross

Place Value Increasing the urban quality and attractiveness of a location







Market Potential Value Increasing market demand and supply



Node Value

London

Increasing the connectivity and accessibility of a location by investing in transit



New York Hudson Yards

Place Value

Increasing the urban quality and attractiveness of a location



Market Potential Value Increasing market demand and supply



Node Value

Increasing the connectivity and accessibility of a location by investing in transit











3V Methodology: HIERARCHIES Pareto distributions

Shanghai population density



Source: World Ban and Chreod Ltd



Source: CASA London: rent per unit area from south





Source: World Ban and Chreod Ltd Shanghai job densities

Source: City of London London energy density

HONG KONG

City of London

Docklands

Job densities

Source: LSE Cities

Method : How to calculate the Pareto exponent? Rank-Size analysis

Kunming

Population Density 2016

Rank-size distribution is the distribution of size by rank, in decreasing order of size. For example, if a data set consists of items of sizes 5, 100, 5, and 8, the rank-size distribution is 100, 8, 5, 5 (ranks 1 through 4).

For checking if a distribution of values of density (people, jobs, GDP, energy, etc.) or of centralities (betweenness) follows a Pareto distribution (inverse power law) and determining the exponent of the power law, you should plot the natural logarithm of the rank on x axis, the natural logarithm of the value on y axis (from the highest value to the lowest) and make a simple linear regression fitting the linear model by using the least squares approach. R2 indicates the fit of the linear model to explain the variance of the log of values according to the log of their ranks. The slope of the regression line gives the exponent of the inverse power law.





Centrality Indexes

Centrality is a structural characteristic of stations (nodes) in the network that quantifies how a station fits within the transit network overall. Stations with high centrality scores are more likely to be key conduits of people and to help concentrate jobs and economic activities. Low-centrality stations can be termed peripheral. Lower centrality is associated with lower growth potential, fewer job opportunities, and lower housing prices . Centralities in transit networks play thus an important role in structuring levels of accessibility, economic opportunities, and market potential. Alignment of land use diversity and intensity of development with centtality creates the maximum TOD benefits



Source: Roth et al. 2012.

Core-and-branches structure of subway network

Efficient subway layouts in global cities, such as Shanghai, Tokyo, Seoul, London, Paris, and New York, converge toward a core-andbranches structure Densely interconnected by crisscrossing lines, the core provides maximum accessibility to jobs and people. It usually extends only about 5 kilometers, because it would be costly to maintain a high density of stations beyond this radius. Outside this area stations tend to be located on branches, and the density of stations decreases sharply when moving away from the city core



3 types of centralities



Degree Centrality

Degree centrality is the number of links per node. Example: London subway network degree centrality

Closeness Centrality

expresses the average distance, measured in number of links, from a station to every other station in the network. Stations who connect to most others through many intermediaries get closeness scores that are increasingly nearer to zero. One property of closeness centrality is that it tends to assign high scores to stations that are near the center of local clusters.

Betweenness Centrality

of a station is equal to the number of shortest paths from all stations to all others that pass through this station. A station with high betweenness centrality has a large influence on the transfer of passengers through the network. This calculation identifies the stations that are necessary conduits for passengers that must traverse disparate parts of the network, such as suburban trains and subway lines or core-andbranches in a subway network.



Example: London subway network closeness centrality



Example: London subway network betweenness centrality

Centralities in New York



Degree centrality

Closeness Centrality

Betweenness centrality

Centralities and Accessibilities in New York



Number of jobs accessible in less than 30-minute door to door by transit



Number of people accessible in less than 30-minute door to door by transit

Source: Urban Morphology Institute

Centralities, Accessibilities, and intensities of land development in New York



New York energy density map per unit of land

Source: MODI Group

First step

Transforming the transit network in a graph

This can be done from the GIS of the network. The main difference between the network in the GIS and a graph is that, in a graph, each interchange station becomes one single point (a vertex also called node or point) which is related to other vertices by edges (also called arcs or lines). Typically, a graph is depicted in diagrammatic form as a set of dots for the vertices, joined by lines or curves for the

edges.



Second step

Calculating each of the 3 centrality subindexes for each node (station)

Once the network has been redrawn as a graph, software such as GEPHI allow calculating each of the 3 centralities. Third step

Producing maps and histograms of the centrality metrics for the entire network

GEPHI allows making maps of the entire graph and histograms of the centralities metrics and to overlay these maps on GIS TAZ maps. This allows checking the alignment between centralities, high place values and projected increases in people and jobs densities. Maximum market potential is created when highest centralities correspond to high place values and to high projected increases in densities (people and jobs).

A drawing of a labeled graph with 6 vertices densities (people and jobs). and 7 edges. Source: Urban Morphology Institute, data from CSTC and KUTI (Kunming Transportation Institute) Kunming Human Density Change 2016 - 2050 Closeness Centrality



0 100 - 0 110

Fourth step Analyzing the structure of the centrality values and their hierarchy

This allows analyzing if there is a strong hierarchy and structure between the nodes in the network (encouraging economic concentration and an efficient overall concentration of densities) or if the network is "flat".

Examples taken from Paris subway network



Source: Urban Morphology Institute



Betweenness centralities follow inverse power laws of exponents close to -1

Stations

3V Node Value Indexes RIDERSHIP and INTERMODAL DIVERSITY

Daily ridership measures the strength of flows of traffic in a node. It is measured by the number of passengers entering a station, excluding passengers not stopping.

Intermodal diversity measures the number of complementary transit modes connecting to a station.

It is measured by the number of lines of different transit modes accessible within walking distance of a station.





Commuting flows hierarchy follows a Pareto distribution Example of Paris

Source: Urban Morphology Institute

Passenger Flows and Place Value in New York





Place value: Red pictures by tourists; blue pictures by locals Source: Eric Fischer

3V Place Value Indexes: Mapping at city scale



Transit community block sizes in Portland



Transit orientation score in 3D in Portland

Source: Portland Transit-Oriented Strategic Plan

Linear density of streets

Street linear density is an index of neighborhood walkability. This index measures the length of streets (km) per square kilometer within each TAZ and within an 800-meter radius of each transit station. It is calculated through street GIS shapefiles/software, such as ArcGIS or QGIS on each TAZ and within an area within an 800–meter radius centered on the station. This index is calculated by dividing the cumulated street length of the street network in the TAZ by the TAZ area.



Ningbo detailed GIS data of Main roads Source: Ningbo Planning Institute



Street linear density distribution in Ningbo

Density of street intersections

Street intersection density is an index of neighborhood walkable connectivity. It measures the number of intersections per square kilometer within each TAZ and within an 800-meter radius of each transit station This index is the number of intersections of the street network in each TAZ (or subway 800 m catchment area), divided by the size of the TAZ in square kilometers (or subway 800 m catchment area). It is calculated through street GIS shapefiles/software, such as ArcGIS or QGIS on each TAZ and within an area within an 800-meter radius centered on the station.



Distribution of street intersections density in Ningbo

Local pedestrian accessibility

This index is also a measure of walkability. It measures the proportion of an area of 800meter radius around a station that is actually reachable in a 10minute walk. It is calculated using open sources software Open Trip Planner Analyst applied to the GIS shapefile of the street network in order to determine the proportion of the 800-meter radius around the station that is reachable by foot within 10 minutes.



Liu Yuan Station

Tu Cheng Station

Golden Triangle

Ten-minute walk isochrones within 800-meter radius of three subway stations in Tianjin, China

Note: Red: Accessibility at 200 meters. Yellow: Accessibility at 400 meters. Green: Accessibility at 800 meters. The green area is used to measure the index.





Prioritizes cars over people Discourages pedestrian activity



Recommended: Dense networks of streets and paths

Prioritizes people over cars Supports pedestrian and economic activity



Dense and connected street networks increase local accessibility **Example of Chenggong in Kunming.**

Source: Energy Foundation and Calthorpe Associates.

Source: Urban Morphology Institute, data from CSTC and KUTI (Kunming Transportation Institute)

Accessibility Proportion of area around the station 0.00 - 0.10 0.10 - 0.20 0.20 - 0.30

Pedestrian



Diversity of uses

This index measures the diversity of types of land use in each TAZ and in each subway station area (within a radius of 800 m around a subway station). It is calculated using the Shannon entropy formula:

 $Entropy = -\frac{\sum_{i=1}^{N} \frac{p_i}{p_N} \log\left(\frac{p_i}{p_N}\right)}{\log N}$

where *i* is the type of use (commercial, community, residential, industrial); *N* is the number of uses; p_i is the area dedicated to use *I*; and p_N is the area of the cell dedicated to any use. The value of a diversity index increases when the number of types increases and evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant.



Source: Ningbo Planning Institute

Ningbo detailed land-use data



For example, land use diversity index for 6 types of uses is calculated by the following formula:

Mix =
$$-\sum_{i=1}^{6} p_i \ln(p_i) / \ln(6)$$

 P_i is proportion of land use type i within TAZ.



Kunming Diversity of uses Within 800m of Stations



Proximity to schools

For each TAZ and each area within 800 m radius from a subway station, this index is calculated by dividing the number of inhabitants living less than 500 m (1000m) from a school by the number of inhabitants in the studied TAZ or station area. It is calculated by creating a buffer zone of 500 m around elementary schools and a buffer zone of 1000m around middle schools and dividing the number of inhabitants living less than 500 m (1000m) from a school by the number of inhabitants in the studied TAZ or station area.



Example: Distribution of 500m buffer of elementary schools in Ningbo

Example: Distribution of 1000m buffer of middle schools in Ningbo

Source: Ningbo Planning Institute

Kunming Proximity to Schools: Elementary Schools Within 800m of Stations Kunming Proximity to Schools: Middle Schools Within 800m of Stations





Proximity to transit stops

For each TA7 and each area within 800 m radius from a subway station, this index is calculated by dividing the number of inhabitants living less than 500 m from a public transport stop by the number of inhabitants in the studied TAZ. It is calculated by creating a buffer zone of 500 m around each public transit stop and dividing the number of inhabitants living less than 500 m (1000m) from a school by the number of inhabitants in the studied TA7 or station area.





Source: Urban Morphology Institute, data from CSTC and KUTI (Kunming Transportation Institute)

Proximity to transit stops in Ningbo selected neighbourhoods

Source: Ningbo Planning Institute

3V Market Potential Value Indexes Mapping at city scale

Human density

This index measures the number of people + jobs per square kilometer in each TAZ and around the transit stations within a catchment area of 800meter radius. It is calculated based on population and jobs data available through the transport model developed for metro lines.

_		1
	0 - 1000	
	1000 - 2000	
-	2000 - 3000	
	3000 - 4000	
	4000 - 5000	
	5000 - 7500	
	7500 - 10000	
5	10000 - 15000	
-	15000 - 20000	
	20000 - 30000	
	30000 - 50000	
	More than 50000	

Example: Human density around transit stations in Zhengzhou, 2009



Source: Urban Morphology Institute, data from CSTC and KUTI (Kunming Transportation Institute)

Source: Urban Morphology Institute, data from Zhengzhou transportation model

People density



Job density



Jobs/Residents Ratio

This index measures the Jobs/residents ratio in each TAZ and within 800-meter radius of each station calculated for 2050. It is calculated by dividing the number of jobs by the number of residents in each TAZ and within 800-meter radius of each station anticipated in 2050.



Source: Urban Morphology Institute, data from Zhengzhou transportation model

Example: Zhengzhou anticipated Jobs/residents ratio in 2030



Human density growth potential

This index measures the forecasted rate of population and job growth over 10–20 years within 800-meter radius of each station

It is calculated based on population and job data available through census or transport model developed for metro lines.



Kunming Human Density Change 2016 - 2050 **Closeness Centrality**

Clo	oseness ntrality of	Human Density Change 2016-2050	
518	tions	People + Jobs/Km ²	
•	0.040 - 0.050	-9070075000	
0	0.050 - 0.060	-7500050000	
0	0.060 - 0.065	-5000025000	
0	0.065 - 0.070	-25000 - 0	
0	0.070 - 0.075	0 - 25000	
0	0.075 - 0.080	25000 - 50000	
0	0.080 - 0.085	50000 - 75000	
0	0.085 - 0.090	75000 - 100000	
0	0.090 - 0.100	100000 - 125000	
•	0.100 - 0.110	and the second s	

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Social composition of the neighbourhood: Average or median income

This index is calculated based on population data available through census or transport model developed for metro lines.

Example: Median income around Paris Grand Paris Express new subway lines





Social composition of the neighbourhood: Percentage of managers in labour force

This index is calculated based on population data available through census.



Source: Urban Morphology Institute



Number of accessible jobs by transit

This index measures the number of accessible jobs within 30 minutes by public transit and foot.

It is calculated with open source software Open Trip Planner Analyst based on population data available through census or transport model developed for metro lines.

Example: Number of accessible jobs in less than 30 minutes by transit in Paris in 2015.

Source: Urban Morphology Institute



Real estate opportunities

This index measures the developable land and developable floor space around each subway station within a radius of 500 meters for the highest market premium and between 500 meters and 1 kilometre for the lower market premium

It is calculated by comparing the GIS map of built densities with a map of regulatory floor area ratio (FAR) and by subtracting existing built floor space from maximum floor space that can be built within the regulatory FAR.



500-meter buffer around Metro Stations in Shanghai



Developable or re-developable sites 500-750- meter from metro stations in Shanghai.



2030 parcels of developable land Within 500-750 - meter of metro stations planned to 2020 in Shanghai

Source: World Bank and Chreod Ltd.

Market vibrancy

This index measures the dynamics of real estate development.

It measures the additional square metres built around stations during the past decade.

It is obtained from local public planning agencies or agencies monitoring real estate activity.



Increase in construction programs between 2000 and 2012 around planned Grand Paris Express subway stations

Source: Salat and Bourdic 2015 © Urban Morphology and Complex Systems Institute.

Policy levers to increase each value

Policy lever
 Increase the number of hubs and the number of lines/modes they connect to. Interlink neighboring stations into clusters. Increase accessibility for all within the network.
 Increase compactness (proximity to existing urban activity and short travel time to main destinations). Increase the diversity of uses. Increase the concentration of commercial, cultural, and educational amenities. Design neighborhoods that promote walking and cycling. Create a vibrant public realm.
Increase residential density.
 Increase job density. Increase human density. Increase the diversity of land parcels to create a vibrant land market. Increase social diversity. Allow for vertical separation of development rights.

More on the 3V Approach at Urban Scale

https://openknowledge.worldbank.org/handle/10986/26405

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Transforming the Urban Space through Transit-Oriented Development The 3V Approach

