From TOD to TAC:

The Transport Policy Shift to Transit Activated Corridors along Main Roads with New Technology Transit Systems.

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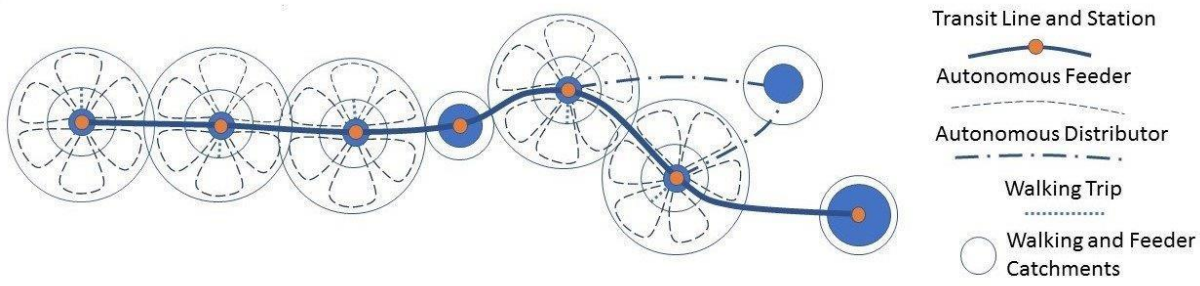
Abstract

Transit Oriented Development (TOD) has long been advocated in transport policy and is accepted as a key way for cities to increase investment in urban rail to reduce car dependence. Despite growing levels of congestion and increasing travel times large parts of the inner, middle and outer suburbs of many cities remain poorly serviced by transit options that do not compete with cars and which do not enable urban regeneration. A new model is outlined to address this double-sided issue called Transit Activated Corridors (TAC) that uses new transit technology along main road corridors to both compete with cars and to facilitate a string of urban regeneration in precincts using private sector funding. Effectively this involves building on the success of TOD's, that were focused on individual rail stations and intended to help transform rail policy, to move to TAC's that are focused on a corridor of transit activated precincts along main road corridors to transform road policy.



The paper develops a set of five 'TAC Design Principles' from a new combination of urban fabric theory with entrepreneurship theory and then applies them to the potential new competitive technologies of BRT, LRT and Trackless Trams, for corridor transit that involves complementary policy around urban regeneration including last mile micro-mobility and new multi-purpose governance systems. The TAC policy would provide main road network managers with better options for delivering both access and amenity.

Keywords: main roads corridors; transit policy; urban fabrics; entrepreneurship; effectuation; Entrepreneur Rail Model; PPP; Transit-Activated Corridor; urban planning.

1. Introduction

Transit Oriented Development (TOD) (Calthorpe, 1993; Cervero et al. 2002) and Transit Adjacent Development (TAD) (Belzer and Autler, 2002; Cervero et al. 2002) are current terminology in transport and land use planning with TAD being called ‘TOD gone bad’ by Reconnecting America (Newton, 2010). Others have suggested Transit Joint Development (TJD) as a concept needed to bring together the necessary public and private sector development opportunities (National Academies of Sciences, Engineering, and Medicine, 2011). All of this literature and practice is based on single entity developments around individual stations or precincts. This paper introduces the concept of a ‘Transit Activated Corridor’ (TAC) which emphasizes the role of new road-based transit technology in enabling denser development along whole main road corridors with a series of station precincts, creating new technology-based urban regeneration in a connected corridor.

The need for TAC’s as a new element of transport policy has been recognised in Europe where the European Commission have strongly recommended cities develop Sustainable Urban Mobility Plans and many other parts of the world have taken up the idea of Movement and Place strategies where the need to do more than simply increase road capacity for more vehicles has become the agenda (Jones and Boujenko, 2009; European Commission, 2020; Victoria Department of Transport, 2019). This has been due to a series of overlapping agendas that include the economics of cities requiring more urban regeneration along main road corridors, the health and environmental needs of cities where traffic is seen to be a major problem, climate change demands for reduced car use and emissions, and the social and political demands of

people for better accessibility (Florida , 2017). However, the delivery of such strategies remains limited as they suggest a need for much more integration with private sector urban development practices and funding/financing, an integration into new kinds of partnerships with all levels of government, an openness to a range of new transit technology and electric micro-mobility and a new way of bringing all this together in terms of multi-purpose governance. All of this goes beyond most transport policy and practice along main roads. It is the purpose of this paper to inform the development of such a new approach, which we refer to as the Transit Activated Corridor approach to transport policy.

2. Theory and Methods

This research paper is the first to combine insights from both urban fabric theory and entrepreneurship theory to develop effective approaches aimed at solving major issues in transport policy using a TAC. Urban fabric theory was sought to help define a new approach to main road corridors that can provide both effective corridor transit faster than the present road system and at the same time enable high-quality urban regeneration along the whole corridor around station precincts. This needs to build upon the qualities of traditional transit urban fabric. Entrepreneurship theory was sought because the approach needs greater integration with new technological innovations combined with private sector developers and their abilities to bring funding and financing into transport systems that unlock urban development. These two theories are briefly outlined before seeking to find useful insights from their integration and focus on the TAC concept that could then be fashioned into transport policy guidelines and applications.

2.1 Urban Fabric Theory

Urban Fabric Theory (Newman, Kosonen and Kenworthy, 2015) is based on an analysis of how cities have created different urban fabrics around their transport choices over millennia due to the travel time budget being a consistent driver of how cities are shaped (Newman and Kenworthy, 2015). It shows that all cities have three cities in their structures:

- **The walking city** in the historic centre densely built with narrow streets usually in a period before mechanised transport;
- **The transit city** in corridors based around trains or trams usually built in the period from 1850 to 1940; and

- **The automobile city** in rings of suburbs built around main road corridors and Freeways from 1940 on.

Urban fabric theory suggests that all three fabrics are merging and need to be recognised, respected and regenerated, but in recent decades the demand has been for more walking fabric (Gehl, 2012) and more transit fabric (Ewing and Bartholomew, 2013; Newman and Kenworthy, 2015, Sharma and Newman, 2017) especially in the rebuilding of earlier automobile fabric in middle suburbs that is in need of regeneration (Newton et al, 2018). The impossibility of building further automobile capacity into such areas and the inability to enable consistent urban regeneration despite increased demand to consolidate cities, has become a major issue in planning and transport policy. This double-sided issue suggests the need for a simultaneous achievement of improved transit down main roads that can be associated with significant urban regeneration.

Effective and efficient corridor transit infrastructure *and* urban fabric improvements, is now therefore a major agenda for most cities. This new market is being driven by the fact that new transit technology is becoming faster than traffic in most cities, creating an opportunity to deliver transit services that are less welfare oriented and more in demand as part of urban regeneration (Newman and Kenworthy, 2015).

Transit Activated Corridors are presented in this paper as a new mechanism to help develop more transit fabric in the 21st century using 21st century technologies and approaches but it builds on these traditional approaches. The theory of urban fabrics is thus used to develop two of the five TAC Design Principles below: one relates to transit fabric and one to walking fabric and both are based on the role of urban planning in establishing the frameworks for such TAC activity. The need for a rediscovery of entrepreneurship approaches is used to provide the other three principles using entrepreneurship theory.

2.2 Entrepreneurship Theory

The transit urban fabric from 1850 to 1940 was created by entrepreneurs along corridors who introduced the privately-operated trams and trains of the 19th and early 20th Century to create real estate opportunities that then paid for the infrastructure (Davies Slate and Newman, 2018). These were typically entrepreneurial projects funded by the private sector as far back as the horse-drawn carriages that ran from the 17th century through to the train era and the tram era (Glaeser,

2012). As there is a growing market for quality transit, especially if it is within a short walk from urban development, then it would seem sensible to involve private entrepreneurs in the development of whole corridors that can provide both new transit and new urban fabric, i.e. new TAC systems. Thus, if this transit fabric is again on the agenda, for 21st century cities, it is important to understand the role of entrepreneurs in the future delivery of TAC's. In our view this approach to integrating entrepreneurship with urban and transport planning and policy has not happened other than through general perspectives that are outlined below.

The study of entrepreneurship is a growing discipline, mostly focused on individual start-up approaches for new businesses, with a lack of consensus on the definition and practice of the knowledge in the field (Hitt *et al*, 2011; Rauch *et al*, 2009). There is general agreement however that a core feature of the practice of entrepreneurship is creating value, often under conditions of uncertainty, and typically to obtain private wealth (Hitt *et al*, 2011) though not without seeing its public benefits. Thinking of entrepreneurship as a process of value creation has led to its broadening beyond just start-up individuals, and towards the traits and approaches sometimes displayed by government and civil society, termed 'Entrepreneurial Governance' (Link and Link, 2009; Olsson *et al*, 2015; Link and Siegel, 2007). Similarly, Harvey (1989) presented 'urban entrepreneurialism' as urban governance that increasingly focuses on '*new ways in which to foster and encourage local development and employment growth*'.

Rather than thinking of 'entrepreneurial approaches' as purely strategies that are applied by individuals or start-ups seeking to grow profitable companies, these approaches can also be used to create value in the form of jobs and wealth, improved use of public space, reduced environmental pollution, alleviating congestion, and delivering cleaner and more efficient cities (Frederick *et al*, 2013). In the same way, this paper refers to principles of entrepreneurship to outline the process of entrepreneurially activating corridors using new transit lines, new partnership approaches and new governance systems – given the entrepreneurial legacy of this process throughout history.

The entrepreneurship literature that seems to provide the greatest guidance on how to achieve the entrepreneurial approaches required for TAC's and to provide the most potential to further enhance its application, is called 'Effectuation' (Sarasvathy, 2009). According to Sarasvathy, effectuation is a logic used by entrepreneurs during new venture creation under conditions of uncertainty, and involves a number of key principles with three particularly relevant to TAC's: create partnerships from the start; value creation rather than prediction; and begin with available means rather than pre-determined ends (Sarasvathy, 2009). These will be used to create the other three TAC Design Principles.

2.3 New Technology for Transit Activated Corridors

As well as using the theories of urban fabrics and entrepreneurship to help show how TAC's can be delivered, the paper seeks to show how new technology is enabling the delivery of TAC's – in transport and urban development. This technology is summarised as new road-based transit systems, new micro-mobility and autonomous shuttles for end-of-trip integration systems, and new precinct-scale technologies.

2.*3.1 New Road-Based Transit Systems*

Traditional transit along main road corridors has mostly been buses with some trams left over from previous eras, generally in conflict with traffic. In more recent times BRT and LRT have increasingly shown that there is a role for road-based transit which is on a lane of their own, that can reach to around 6-lanes equivalent of car traffic (Vuchic, 2005; Schiller and Kenworthy, 2019). Increasingly these systems have improved their service quality (Hidalgo and Muñoz, 2014) through enhanced vehicle guidance, low floor disability access and stabilization of sideways movement. But the arrival of electric transport through batteries carried on buses has revolutionised these systems with quieter, emissions-free systems similar to light rail. All of these transit electrification projects involving batteries, can make TAC's part of facilitating climate change-based transformation to zero emissions transit where renewables are built into station precincts, with the potential to move towards a new grid stabilisation system (as further outlined below).

Road-based transit was given a significant boost when a new transit technology was discovered that we have called a 'Trackless Tram'. The Trackless Tram Systems (TTS) have taken six innovations from High Speed Rail, put them in a carriage bus – or tram like vehicle - with

stabilization through bogeys and optical guidance systems, that not only mean it is largely autonomous (though not completely driverless), but it is also enabled to move at speed down a road with the ride quality of a light rail. Being electric through batteries and with no need for steel tracks, it is significantly cheaper and easier to implement than a light rail. It is also much better than traditional BRT at being able to attract urban development around it though new European and Chinese electric buses are showing that there are likely to be significant improvements in facilitating urban development (eg the new Brisbane Metro). These innovations in ride quality and speed as well as the electric traction now in all three on-road systems, has helped to make new transit technology for BRT, LRT and TTS much more attractive to urban development partnerships.

Research was conducted on assessing this technology (Newman *et al* 2019) and the conclusions in this rapidly changing area of mobility, would now be more supportive of BRT's like the new Brisbane Metro. In reality these on-road transit systems are merging into a powerful new system that should be able to help create TAC's as set out at the end of this paper.

The different road-based transit systems will require assessment in different cities but an approach is suggested below using the five TAC Design Principles developed from the three entrepreneurial principles and the two urban planning tools which can make the most of this important characteristic of attracting private development into precincts around stations. This enables a high-level approach to assess the potential to deliver very efficient and effective transit activated corridors.

2.3.2 New Micro-Mobility and Autonomous Shuttles for End-of-Trip Integration Systems

Micro-mobility electric scooters, skate boards, bikes and autorickshaws are ideal ways to enable end-of-trip integration, and can work with autonomous shuttles to provide an integrated Mobility-as-a-Service offering for end-of-trip travel. New transport options presented by emerging technologies will require management to enhance station precincts for walkability and not promote more car-dependent end-to-end travel (Currie, 2018). This should include how driverless electric shuttle buses can carry people to the station precincts (providing first and last kilometre solutions) without ruining the walkability qualities of the area (Glazebrook and Newman, 2018).

Evidence is showing that Uber (and potentially driverless vehicles) are increasing the vehicle kilometres travelled (VKT) rather than decreasing it as many had anticipated, causing greater

congestion and accessibility issues (Schaller, 2018). To counter this trend will require a different approach to mobility and TAC's are likely to be part of this through new technology options that favour road-based transit integrated with these end-of-trip options. Recently emerging e-scooter and car sharing business models may hold the key to reducing car ownership and use, and reinforcing TACs. Membership of car-sharing services has been shown to reduce vehicle use and car ownership rates (Muheim and Reinhardt, 1999; Becker, Ciari and Axhausen, 2018) which may enable a balance to be obtained with demand-based systems like Uber/Lyft and autonomous vehicles (Calthorpe and Walters, 2016).

2.3.3 New Precinct-Scale Technologies

Precincts need to be built in a chain along the Transit Activated Corridor and this period of technological advancement is developing systems that work best at a precinct-scale, like solar, batteries, new small scale water and waste systems, and new local electric transport systems (Thomson, Newton, Newman and Byrne, 2018; Newton and Taylor, 2019). Each precinct along a corridor will also have their own special place and purpose in the TAC chain. This special quality of place-based urbanism is fundamental to any urban regeneration as will be the need for biophilic features, circular economy materials and carbon positive buildings (Caldera et al, 2019). But most importantly the necessary uplift in value that can release the funding/financing of a series of urban regeneration projects (seeking such new technologies), will only happen if there is a strong and competitive new technology transit system feeding the residents, workers and visitors to the precinct. Each precinct will therefore be an opportunity to show how they can use new technology in their project and most importantly how they can link into the new technology transit system.

As outlined above all of the new transit technologies will be electric with last mile linkages being electric as well. Thus, each of the precincts will need to have a station with potential to recharge a Trackless Tram, LRT or BRT and a set of buildings with potential to collect solar energy (or create Hydrogen for use in Fuel Cell Vehicles). Thus, the whole corridor can be part of the power system and indeed with battery storage at stations there is potential for them to be Recharge Hubs for all the micro-mobility and autonomous shuttles feeding into the station.

Vehicle to Grid (V2G) services can be designed to allow electric vehicles to contribute to storage and grid stabilisation, increasing grid efficiency, stability and reliability (Yilmaz & Krein. 2012).

Greater connectivity between vehicles and the grid will likely allow for discharging of power from transit and other vehicles when not in use, to respond to times of key peak demand. This is known as peak shaving. Eshani et al (2012) provide six potential services that electric vehicles will likely provide grids in the future ranging from peak shaving for between 15 minutes to 2 hours, down to assisting the starting of electric motors that require high-intensity electricity for a short period of approximately 15 seconds. Moving from theory to practical application in this area is still a focus of research and innovation efforts (Uddin et al., 2018; Saldana, 2019).

What the Transit Activated Corridor adds to this literature is the potential innovation to create Recharge Hubs at station precincts. These will be able to help all kinds of electric vehicle recharge, especially micro-mobility feeding into the electric transit that are suitable for constrained spaces. The new precinct developments can be built with solar PV covering all available roof space and extend out as far as is needed to ensure sufficient power can be provided locally. Recharge Hubs should also provide grid stabilization services in this transition to zero carbon grids.

3. Results:

3.1 Five Design Principles for Transit Activated Development

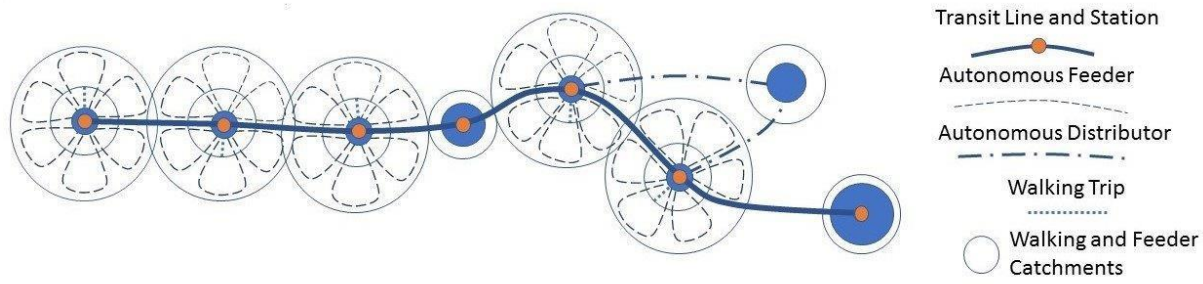
TAC Design Principle 1: Define Transit Activated Corridors

The first planning tool comes from how Urban Fabric Theory shows the importance of transit corridors. These were the Transit City fabric developed along first train and then tram corridors in the periods described above in urban history. These are now highly sought-after urban fabric for living and working due to their quality to provide multiple accessibility options and mixed land use services. To convert a Main road corridor into a TAC requires both strategic and statutory planning that are focused on a particular corridor. It will need a high-quality transit system and it will need the corridor to be declared or zoned as *primarily for transit and dense urbanism*.

A series of such plans are being developed around the world since Transport for London declared their policy called ‘Street Families’ (Transport for London, 2013) which sets out the streets that give priority to transit and where density will be given special encouragement. The ‘Movement and Place’ framework has gained traction which recognises that streets are not only

about moving people from A to B, but in many contexts also act as places for people and public life. The Movement and Place framework enables the 'place' prioritisation of streets to create walkable, liveable centres along the whole corridor. In Perth the approach has been proposed to create a 'Green Route' that requires transit priority and density to be the joint focus along the road. Such routes could be specified as potential Transit Activated Corridors with associated zoning along the corridor.

Figure 1 shows the main idea of a Transit Activated Corridor. Source Glazebrook and Newman, 2018



This approach is increasingly being used in the UK and Europe more generally as part of 'Sustainable Urban Mobility Plans' (Eltis, 2016). The approach is outlined in Table 1 below. TAC's can support all of these goals.

Table 1 Summary of Guidelines for Sustainable Urban Mobility Plans compared to Traditional Planning. Source Eltis, 2016

Traditional Transport Planning	>	**Sustainable Urban Mobility Planning**
Focus on traffic	>	Focus on people
Primary objectives: Traffic flow capacity and speed	>	Primary objectives: Accessibility and quality of life, as well as sustainability, economic viability, social equity, health and environmental quality

Traditional Transport Planning	>	Sustainable Urban Mobility Planning
Modal-focussed	>	Balanced development of all relevant transport modes and shift towards cleaner and more sustainable transport modes
Infrastructure focus	>	Integrated set of actions to achieve cost-effective solutions
Sectorial planning document	>	Sectorial planning document that is consistent and complementary to related policy areas (such as land use and spatial planning; social services; health; enforcement and policing; etc.)
Short- and medium-term delivery plan	>	Short- and medium-term delivery plan embedded in a long-term vision and strategy
Related to an administrative area	>	Related to a functioning area based on travel-to-work patterns
Domainof traffic engineers	>	Interdisciplinary planning teams
Planning by experts	>	Planning with the involvement of stakeholders using a transparent and participatory approach
Limited impact assessment	>	Regular monitoring and evaluation of impacts to inform a structured learning and improvement process

A core part of designing TACs would be a set of detailed design options for how a transit service could travel at speed down a clearway where possible, and then slow down when it enters a station precinct where the design and place focus would be to facilitate walkability and

pedestrian activity. This would send the signal that dense urban development would be favoured as it would have a high-quality transit system linking it to the rest of the city and would have a highly attractive urban design quality for attracting people-based activities in and around the stations. This could be called a '70:20 strategy' as the aim would be to bring the road-based transit down the corridor at speed (70 kph max) and then slow down to prioritise walking (20 kph max). This is a very different approach than on railways and on traditional main roads which separate out urban development from the mobility goals along the different modal routes.

The responsibility to enable TACs would necessarily require multi-purpose governance. Perhaps an agency, or cross-agency group, could have both responsibility for delivering transit and delivering urban regeneration. Thus, roads chosen for this category would shift their priority for providing mobility services for 'through traffic', to a focus on how they could enable quality transit and urban design along the corridor that delivers value to both developers and the community requiring mobility along the corridor. This would mean more of a focus on accessibility, sustainability and equity. Compared with car only lanes such routes could carry the equivalent of 6 lanes of traffic (Newman et al. 2019) easing congestion issues while increasing activity along the corridor through transit and urbanism.

TAC Design Principle 2: Create Walkable and Sustainable Station Precinct Design

Urban Fabric Theory also shows the significance of walking city fabric. These are the dense centres where walkability is given the highest priority and these were traditionally around the old city centre. They are now being created as transit oriented precincts but within a new TAC they need to have a sustainability orientation that can be tapping new zero carbon technologies for power as well as new micro-mobility and autonomous shuttles for last-mile access.

Station precincts must be allowed to be dense and mixed use in the strategic and statutory zoning systems used to enable TACs. There are a large number of design tools created to make station precincts into 'inclusive, safe, resilient and sustainable' places including walkable urban design, solar design, water sensitive design, biophilic design, affordable housing design and most of all integrated design (Caldera *et al,* 2019). For instance, there are a number of detailed manuals from the Congress of New Urbanism that set out best practice in these areas (CNU and Talen, 2013; Tachieva, 2010; Benfield *et al*. 2001; Dunham-Jones and Williamson, 2008). Such guidance now needs to be reflected in statutory requirements for station precinct developments along transit corridors and wherever possible updated to include these new technology options.

TAC Design Principle 3: Create partnerships from the start

The first principle drawn from Entrepreneurship Theory is to *'create partnerships from the start'* By creating a group of partners and stakeholders from the beginning, it reduces uncertainty and risk as a co-created vision is developed between all parties and is realised through collaboration (Sarasvathy, 2009). Just as expert entrepreneurs build partnerships from the start, a TAC project would begin with a partnership between land interests, communities, local authorities and financiers, and then would reach agreement with government though it is also possible for government to bring these groups together in partnerships during a procurement process. The key is to have the partnerships formed early not after the transport has been planned and built. Effectuation suggests that 'self-selecting stakeholders' tend to have more commitment to the project and in the case of private funding and financing of urban rail projects, self-selecting stakeholders are often able to reach agreements around the distribution of benefits and costs more easily (Zhao *et al*, 2009).

These partnership-first approaches have been growing rapidly around the world in recent years, taking the place of siloed professional practice (Clark and Clark, 2014; Newman, 2016). For cities and infrastructure, this partnership approach has sometimes been called a 'City Deal', and enables a more bottom-up approach to infrastructure planning and provision. These new approaches will be important for involving private funding to help fund the capital costs involved in quality transit projects (Newman *et al*., 2017b). The Australian Federal Government has followed the success of the UK City Deal policy and has created a program based on this concept to encourage urban renewal (Australian Government, 2018). The City Deal program includes requirements to enable (Glazebrook and Newman, 2018):

- An agreement between the three tiers of government, setting out a plan for the City Deal to accomplish innovation, affordable housing and sustainability outcomes.
- Greater community involvement and support for any projects, and
- Involvement of the private sector, including innovative financing that integrates transit and land development, and with supporting funds from local and state government, with the Federal Government providing a risk guarantee.[1]

[1] This is based on the UK's Infrastructure and Projects Authority which has attracted several billion pounds of private funding into British infrastructure over the past two years.

Another key feature of the City Deal approach is it provides an effective mechanism to align the policy intent of the different tiers of government. This provides greater clarity to the private partner, reducing risk, and facilitates co-ordination with other government programs.
City Deals are well-suited to facilitating Transit Activated Corridors, as they can provide increased regulatory certainty or guidance along the corridor, by aligning the objectives of the different tiers of government and can enable the private sector to obtain their finance.
Agreements can also be reached with multiple levels of government to provide associated public infrastructure work such as recharge services for stations where electric battery recharging is needed. All of this is likely to increase value in projects as determined by entrepreneurship theory.

TAC Design Principle 4: Value creation rather than prediction

The second principle drawn from Entrepreneurship Theory is to focus on what can be controlled to '*create value rather than to act based upon predicted outcomes'*. In practice, according to Sarasvathy (2009), this means expert entrepreneurs focus on the controllable aspects of an unpredictable future rather than actions based on predictions of an uncertain future. Some of the mechanisms for capturing value created by the transit system are set out in Newman *et al* (2018), including the highest value-producing mechanism of a fully-private entrepreneurial approach through to the lowest value-producing fully-public approach where private developers can only add value after everything else is decided. various levels in between.
Currently, transit corridors are assessed based on predicting the number of people who would potentially use a new mass transit system based on present land use and travel patterns. Some governments seek to finance this through public funds or additional rents and land-based charges imposed on surrounding land owners. Traditional government value capture approaches rely on a 'predicted return', whether this be a predicted number of passengers, a predicted reduction in congestion, or a predicted amount of development. This approach suggests value capture can be managed; however most of the value leaks as soon as a route and set of station locations with density zoning is made public, unless partnerships with entrepreneurs are made at the planning stage.
There is also an issue with prediction. Transport planners have struggled with prediction, particularly for road networks, due to the principle of induced demand which causes unexpected behaviour from commuters when new travel options become available (Levinson *et al*, 2017). A

prime example of this is that despite providing additional vehicle lanes to relieve congestion, the new lanes are unable to provide lasting congestion relief, due to travellers losing travel times, then shifting routes, and modes when networks are changed. This is referred to by Downs (1992) as the theory of triple convergence and it leads to ineffective prediction-based interventions. This effect can also occur when forecast-based transit interventions deployed in isolation of land development are undertaken and can result in less-than-expected reduction in traffic congestion (Litman, 2017). Means of overcoming this in Europe are set out in Principle 1 using Sustainable Urban Mobility Plans.

The entrepreneurial approach in Transit Activated Corridors creates complementary opportunities for both new land use investment and increased transit ridership which is not possible through current transit planning. There is ample record of this being done historically (Davies-Slate and Newman, 2018). This is made viable through integration of private land development with transit services to create station precincts or corridors which creates two increased sources of value: one is due to the land value increases of between 20% and 50% usually associated with transit (summarized in Newman, Davies-Slate and Jones, 2017) which enables higher density development; and second, a reduced need for expensive car parking infrastructure of around 20% which enables better urbanism (Newman et al, 2018). There is a strong relationship between the availability of parking and private vehicle mode share (Shoup 2011; 2018) The result of greater value increase is that it can also mean investment to construct the transit infrastructure so that the value is created. It is in this way that the entrepreneurial approach 'creates new markets' that government planners cannot achieve on their own, even when they have development powers. This value increase can only be achieved in partnership with governments that manage the common good outcomes necessary but are freed from the need to raise all the funds.

This entrepreneurial approach was used by Hong Kong in its metro and in the development of the private suburban railways in Japan, primarily in the first half of the Twentieth Century. Railway companies augmented their transport revenue through real estate development and management, but also proactively managed land uses around their stations to influence passenger demand. Land was provided to institutional users such as hospitals or universities at concessional rates at the outer terminal stations, creating demand for travel in the reverse direction from central business district commuting patterns (Cervero, 1998). The private railways had to diversify in this way to survive, as the Japanese Government had partially nationalised the

industry to create the Japan National Railway. Private companies were forbidden from building railways which interfered with the national railway's operations, and were mostly restricted to areas with low population. This forced them to build their own catchment population around their railways (Saito, 1997), making the best use of the assets at their disposal. This is a good example of a TAC that was privately created but had significant benefits to the wider community.

Thus, value creation can be applied to the TAC model using value uplift in land development to create value for the transit funding, rather than the value capture or value leakage that occurs under the present approach to 'predict and provide' transit, leading to limited interest in transit projects. The success of the Brightline private rail project in Florida has shown that the approach can work in more car dependent cities and regions; this project was funded and financed through land development and fare box returns and has now been purchased by Virgin Trains USA with plans to extend into 20 other cities.

In cities that do not have such attractive land development potential as does Hong Kong, Tokyo or Florida, this approach can be taken a step further to attract private investment in transit infrastructure. Rather than just buying pre-rail land and selling it at post-rail prices, the partnerships with land owners and developers can be expanded to capture even greater value around stations. This can be done by incorporating developer preferences for the location of the transit line and associated stations to allow for fully private transit lines to be constructed and operated in unison with new developments (Newman et al, 2017; Davies-Slate and Newman, 2018; Newman et al, 2018). Coupled with this, there are technological innovations occurring in the transport technology sector that are providing rail-like solutions at a much cheaper cost, discussed below.

Such an approach stands to provide cities and nations with a way to break out of the gridlock of automobile dependence and under-financed transit by harnessing private investment to deliver integrated transit and land development along corridors. This way enables value creation from the transit that can be used to contribute to the costs associated with delivering the transit without driving away investors and developers. The assessment process will need to find ways of including this extra value in Benefit Cost Ratios.

TAC Design Principle 5: Begin with available means rather than pre-determined ends

The third key principle drawn from Entrepreneurship Theory is to '*begin with a set of available means, rather than pre-determined ends*' (Sarasvathy, 2009). This requires thinking differently about what constitutes a cornerstone for action, innovation and finance. During new venture creation, expert entrepreneurs tend not to decide upon a 'final product' and then seek to assemble the required resources, but instead begin with what is available, giving preference to actions which harness available resources or networks and which appear to help with their perceived journey.

Unlike the current approach to transit which seeks to predict and build transit infrastructure based on current conditions and reliant on government funding, this principle suggests that instead of using a pre-determined route and trying to 'add on' land value creation at the end, the 'available means' or available land opportunities are in fact the basis for the viability of the entire project and need to be considered right from the start.

Despite entrepreneurs often being considered 'risk takers', expert entrepreneurs seek to minimise risk by 'controlling the downside scenarios and finding ways to reach the market with a minimum expenditure of such resources as time, effort and money' (Sarasvathy, 2009). This means entrepreneurs seek to creatively leverage underutilised or 'slack' resources, such as land development sites that can be made viable through transit accessibility. Such development opportunities can then provide a powerful dynamic in the process to design and deliver transit infrastructure. Hence, rather than having a fixed route and set of station locations in mind, the process can begin with a configuration that best leverages investment in the early stages. As station precincts then begin to be built and create more value, the investment in the transit can continue to grow to provide greater services and station precinct locations. Organic growth of a TAC project can be based on stages that depend on what the land development market can achieve. Examples of this organic process can be seen in the United States in the development of new corridor rail lines based on a series of TOD's built in stages. Business Improvement Districts are a model that can be applied to TAC's, as are the Tax Increment Financing projects in Pearl District, Portland, and the South Lake Union Streetcar in Seattle. A similar idea is being developed for the El Camino Real in Northern California by Peter Calthorpe (Scherba, 2018).

In practice Transit Activated Corridors raise investment for transit through partnerships that grow organically as the land development opportunities are realised and expanded. This

minimises risk for participating private parties and increasingly shifts towards private funding to complete projects. Hence this can reduce government's role especially in terms of having to raise the full capital (increasingly difficult and compared with the TAC model less value creating) allowing a focus on roles more aligned to the purview of government such as being critical in the delivery partnerships. Government needs to provide creative leadership on zoning, planning integration, and facilitating connections to the wider transit network. Government can also assist with land assembly and risk management in procurement (Newman *et al*, 2017), easing the process for private parties to participate and creating new value. Similarly, for the public sector, project-based implementation risk is reduced through sharing with the private sector in this organic stepwise process.

The application of these three principles of entrepreneurship will be a key foundation for Transit Activated Corridors as well as the more usual government tools in urban planning outlined from urban fabric theory. Together the 5 TAC Design Principles enable partnerships with developers and investors, to design, finance and deliver Transit Activated Corridors.

3.2 Applying the 5 TAC Design Principles to New Transit Technologies for Road Corridors

The core requirements from the five principles for TAC are applied to the three options of BRT, LRT and TTS and are set out in Table 2. This enables us to see how well the new technology of TTS promises to facilitate a TAC.

Table 2. Comparison of TAC Design Principles for corridor based urban rapid transit systems of BRT, LRT and TTS.

Principle 1: Ability to service transit corridors (TAC route)		
BRT	If strategic plans are developed mode agnostically, BRT is competitive on infrastructure cost and speed if given priority. However, it will not achieve urban regeneration outcomes as well unless using new technology electric systems.	✓
LRT	If strategic plans are developed mode agnostically, LRT is competitive on capacity per vehicle, speed and ability to attract regenerative investment.	✓
TTS	If strategic plans are developed mode agnostically, TTS can enable the capacity and speed of LRT but has potential to cost much less. The ride quality is indistinguishable	✓✓

	from light rail, however has additional advantages for service reliability, such as the ability to move around obstacles.	
Principle 2: Ability for integrated application of walkable and sustainable precinct design tools		
BRT	The same precinct design principles can be applied but without private investment they rarely happen. Thus, a new technology BRT could attract new precincts and involve more walkable and sustainable design at stations.	✓
LRT	Able to utilise best-practice integrated precinct design from light rail projects to achieve walkable, people-centric and sustainable transit precincts but depend a lot on public commitments and local government.	✓
TTS	Design tools for precincts would be just as effective in station precincts around Trackless Trams as around LRT except the trackless tram requires less infrastructure (no overhead wires, no rails in the ground). Compared to light rail, trackless tram projects likely have lower complexity and cost that generally contribute to the need for LRT to be driven by governments, and thus trackless trams create opportunity more 'ownership' from precinct developers.	✓✓
Principle 3: Ability to facilitate partnership-driven planning		
BRT	BRT is able to achieve partnership-driven planning, however partnerships are generally transport-centric given the lesser urban regeneration ability achieved by traditional bus-based schemes. If BRT switches to new electric buses this may change.	✓
LRT	LRT is able to bring transit, land development and community interests to the table and this has been demonstrated around the world, including in the case studies above.	✓✓
TTS	TTS are able to bring the same interests together as LRT to plan a transit project financed by urban regeneration, however TTS can enable the inclusion of far more parties than under the recent welfare finance model of most light rail due to its lower cost. Projects do not need to be large in scale to get started, and have less risk. An inclusive, bottom-up, community-engaged planning approach can be achieved with the less expensive trackless trams.	✓✓✓
Principle 4: Ability for value creation through urban regeneration		
BRT	Bus-based systems have had less urban regeneration success in most cases but this can now change with new technology.	✓
LRT	Light rail has been successful in attracting investment and urban regeneration around its lines, especially given its fixed nature, however urban regeneration is best achieved if land development is used as the cornerstone of transit finance such as proposed here.	✓✓

TTS	Ability to be used like light rail, particularly through an entrepreneurial financing process to ensure urban regeneration is undertaken, but at what is likely to be a lower cost.	✓✓
Principle 5: Ability for organic resourcing through staged financing		
BRT	The lack of strong urban regeneration attraction created by BRT systems creates a lack of investor incentive for the finance of new lines. If BRT organically grows into use of better technology especially electric buses then it will be much more able to move into organic expansion using private land development funding and financing.	✓
LRT	Has been achieved in a number of cities, highlighted in case studies above.	✓✓
TTS	Organic resourcing through staged financing would be similar to the LRT as in the case studies outlined above. At each stage of financing the two parts of the TAC, the Trackless Tram and the chain of TOD's could be financed with steps assessed for land value uplift, patronage and other benefits and costs, before proceeding to the next stages. Trackless tram 'trials' (shorter sections of routes) are much more feasible than the LRT equivalent, particularly if laid on existing road base as has been done in early Chinese routes such as Yibin's ART route to familiarise people with the route and technology.	✓✓✓

The high-level assessment would suggest there is a very high capability of all the new technology road-based transit, especially Trackless Tram Systems, to enable a TAC to be created with a quality transit corridor and a chain of high quality innovative precincts linked to it. These results are summarised in Table 3.

Table 3. Indicative comparison of TAC Design Principles for corridor based urban rapid transit systems in terms of entrepreneurship and urban planning factors supporting a Transit Activated Corridor.

TAC Design Principles in Terms of Ability to Use	**Bus Rapid Transit (BRT)**	**Light Rail Transit (LRT)**	**Trackless Tram System (TTS)**
1. Strategic TAC Route	✓	✓	✓✓
2. Design Tools for Precincts	✓	✓	✓✓

3. Partnerships	✓	✓✓	✓✓✓
4. Value Creation in Urban Regeneration Potential	✓	✓✓	✓✓
5. Organic Resourcing through Staged Financing	✓	✓✓	✓✓✓
Overall	✓	✓✓	✓✓to✓✓✓

4. Conclusion

Growing cities around the world are looking for new ways to deliver transit and urban redevelopment. This paper suggests a new option called Transit Activated Corridors (TAC) and sets out how best to achieve them using five principles drawn from urban fabric theory and entrepreneurship theory:

(1) *Define transit activated corridors,* that suggests a high-level strategic plan to develop Transit Activated Corridors (like the European Sustainable Urban Mobility Plans) with statutory mechanisms that require the delivery of transit priority as well as dense, urban regeneration, and providing a delivery agency focussed on this task; and

(2) *Walkable and sustainable station precinct design***,** that would mean a series of statutory design requirements for the station precincts to be high quality designed precincts for walkability, affordability and sustainability using new technology.

(3) Create partnerships from the start, that suggests for TAC the need for partnerships between government, community and the private sector which can leverage such entrepreneurial approaches similar to the historic role of entrepreneurs in creating train and tram corridors, and the emerging models for involving the private sector in rail developments, especially involving partnerships such as City Deals;

(4) *Value creation rather than prediction,* which suggests that TAC projects can take value creation opportunities through involvement of private sector financing of land development rather than simply predicting transit outcomes as in current transit planning;
(5) *Begin with available means rather than pre-determined ends,* suggesting that TAC could use available resourcing from land development in organic steps to stage the financing.

All these require the private sector to be actively involved from the beginning of the planning process, providing the opportunity to collaboratively shape and capture benefits from transit activation along the corridor, creating the basis for the private sector to contribute financing given the attractive development opportunities that exist.

When the five principles were applied to a high-level assessment of the emerging transit technologies for road-based transit with new BRT, LRT and Trackless Trams, it showed that these lower cost new technology options are likely to help with the design, financing and delivery of a Transit Activated Corridor down urban streets, with the new technology Trackless Trams especially strong.
The TAC policy would make a whole new option for main road network managers to enable better options for both access and amenity to be provided.

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