Short Report on:

Inquiry into the utilisation of rail and infrastructure corridors

Prepared for the NSW Legislative Assembly,

Committee on Transport and Infrastructure

29 February 2012

Contact for further information

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Summary: Parliamentary Inquiry into the utilization of rail & Infrastructure corridors.

This report to the parliamentary inquiry addresses the use of land development for integrated infrastructure corridors and considers improvement to policy development, planning and strategies to achieve greater productivity, enhanced liveability and improved economic benefit through informed decision making.

In considering rail corridor usage long term it is essential to support the needs of society through decision making that is underpinned by proper analysis and longer term modelling. In order to ensure any proposed interventions represent a step forward with respect to competiveness of the transport system, the liveability for affected residence and customers and the overall resilience to unexpected events. This report cites a number of case studies from Europe, Asia and the Americas where an informed and structured approach has yielded positive results.

In NSW there is a unique opportunity for the government either in partnership with private developers or through government investment to transform the airspace and surrounding precincts to stations and rail corridor land to create modern residential, commercial and logistic developments. Development should aim to transform existing communities, develop attractive residential, community and commercial facilities, improve productivity, facilitate freight logistics, ease road congestion and add to economic capacity.

To access private capital for the development of rail corridors, stations and rail infrastructure facilities, an approval framework where risk is transparent and which bridges across legacy and sometimes lengthy approvals system is deemed to be essential.

We have highlighted examples from five progressive cities, Perth Australia, Naples Italy, Stockholm Sweden, Arlington USA and Singapore where there are lessons to be learned associated with rail land development. There are many more cities where a transport orientated development (TOD) approach has been followed, this input to the inquiry brings forward experience from some of these cities and considers that benefit would be gained through comprehensive research in this area.

We recommend that when undertaking corridor development the widest possible range of options be taken into the planning stage so that what is critically essential to the efficient and effective functioning of our society may be supported. In the transport sector improving the movement of goods and people through intermodal interchanges where diverse transport modes are facilitated and designed in, will greatly enhance the working of our city. Freight transfer from high productivity road trains to the commercial light van distributers, the rapid and efficient interchange between bus, light rail and commuter rail services along with consideration to the smooth passage of people through stations, car parks, residential and commercial premises are all key considerations as far as development of rail land and corridors are concerned.

Good Practice Adoption

This report examines a number of case studies to illustrate transport related development practices adopted around the world where good practice can guide considerations into rail corridor development here in NSW and in developing a vision for rail corridor development the following are applicable:

- Development of corridor and rail lands at stations and other installations can yield a 10% land value uplift which should be harnessed through some form of market based financing.
- Rail freight growth is projected to double by 2030 and rail corridor development to support this growth needs to have priority in any future utilization considerations.
- Rail corridor development needs to cater for mixed land development to provide wide benefit to the community and the economy through consideration to the needs for public amenities, housing, freight hubs, retail outlets and commercial facilities.
- Rail corridor development should aim to deliver better transport connectivity through new and improved intermodal interchange hubs that include car and bus parking, bulk freight to freight distribution exchange, road to rail passenger and freight transfer. Specific attention is recommended to facilitate pedestrian and bike access to passenger transport along with secure bike parking.
- How communities are involved with development proposals and how planners proactively anticipate the effects that proposals will have on individuals and the choices they make should be explored through simulation and modelling the geo spatial and general consequences of an intervention.
- In developing rail corridors NSW could do well by adopting the principle that facilities and station developments should cater for the lifestyle needs of the customers they serve by providing environments that are sought out by the public and traveller alike just as in the Hong Kong case.

Our input and advice to the inquiry first looks at the factors influencing land use which will also be important in rail corridor utilisation. Following this we then consider how simulation and modelling support the framework for managing land use. The further sections encourage the development of a vision for rail corridor development followed by considerations for funding and interesting case study learning leading the opportunities for NSW.

About SMART Infrastructure Facility

The SMART Infrastructure Facility at the University of Wollongong was established to develop an integrated approach to infrastructure planning. Australia's first research centre dedicated to infrastructure was funded by the Federal Government, the NSW Government via RailCorp and the University of Wollongong.

SMART stands for 'Simulation, Modelling, Analysis, Research and Teaching' and our work approach is multidisciplinary and collaborative. We have established Australia's first Professorial chairs in infrastructure economics, infrastructure governance, infrastructure systems, and infrastructure modelling and simulation.

SMART has set out to provide the research, knowledge and tools required for evidence based public policy and investment decision making.

Our research and teaching focuses on four practical themes:

- Infrastructure governance and project evaluation
- Infrastructure systems and complex modelling and simulation
- Infrastructure data aggregation and analysis
- Rail Logistics

Our mission is to generate, publish and disseminate ideas that support greater understanding of the interconnection and interdependencies of infrastructure.

The SMART Rail logistics division is establishing a research capability to support and champion the role of rail as part of the broader transport network in Australia. We are focused on pushing research boundaries to develop a rich inter-disciplinary fabric to ensure Australia is best placed to be more efficient and resilient in its rail logistics task of freight and people.

1: Introduction to Infrastructure land use

Planning for land allocation to enable a proper mix of land use, which will increase the welfare of communities and the nation is a complex and challenging task. Increasingly, the complexity has grown widely due the range of inter-connected problems that planners have to deal with. Planning considerations range from population growth; an ageing population and other demographic change to increasing congestion and delays in getting to work. Moving goods and services around cities; ensuring adequate energy and water supplies; adapting to climate change; higher aspirations for liveable cities including green spaces and preserving natural and historical heritage also have to be considered; while maintaining buffer zones for ports, etc and natural hazard areas; and the growing expectation of residents that they should be consulted on changes to their neighbourhood must also be catered for.[1]

Various infrastructure players include water and sewerage systems, road and rail networks, communications systems, human services facilities such as schools and hospitals, along with parks and open space. These infrastructure systems are interconnected, further complicating efficient and effective planning.[2] Planning of each of these infrastructure systems individually can adversely affect other systems and it is not surprising that private sector developers front load risk on planning approvals when assessing developments. For existing rail corridors therefore will benefit from an approvals framework which is transparent and simplified in order to encourage private sector investment.

[1] Productivity Commission (2011), Performance Benchmarking of Australian Business Regulation: Planning, Zoning and Development Assessment, Research Report, Canberra.

[2] Wilmoth, D. (2005) *Urban infrastructure and metropolitan planning: connection and disconnection*, Proceedings of the 2nd State of Australian Cities Conference, Urban Research.

Congestion in major Australian cities is on the rise, it is predicted that for the cost burden of congestion for Australia's five largest capital cities, unless addressed, will double to about $20 billion by 2020. This would impact the movement of people and goods around cities.[3] Therefore, it is necessary to holistically improve railway corridor use in Australia together with its inter-linkages with various land use planning activities. This will involve concentrating urban development around stations in order to support transit use, and developing transit systems to connect existing and planned concentrations of developments effectively to existing urban infrastructure to deliver.

a) *Reduction in car dependence*: development on rail corridors of centres with appropriate density & mix, with transit system between centres can help in significantly reducing community car-dependence and increasing public transit system as a modal choice.

b) *Assist cities in their wealth creation*: by reducing expensive car based travel. It is estimated that car travel cost around 85c per passenger kilometre compared to 50-60c per passenger kilometre in transit.[4] Newman[5] has indicated that cities like Hong Kong, Tokyo, and Singapore have ten times the per capita wealth of Bangkok Seoul, Beijing, but per capita case use in less. Many wealthy cities have focussed on developing good transit infrastructure.

c) *Save commuting time*: Easy connection with fast transit system based on electric rail can save time for local and long distance travel. Rail gives transit an edge in speed which is faster than bus based transit.[6] Also it is the only transport mode that can quickly move large volumes of people over 50 thousand per hour.

d) *Save space*: Space requirements for car dependence are 20 times more than those of rail.[7] It has been predicted that if 200,000/day of people who access central Sydney had to get there by car it would mean an extra 65 freeway lanes and 782 ha for car parks.[8]

e) *Realise investment opportunity*: [9] More than 30 studies in US involved improving access to rail station provided proven land value premiums and rail corridor utilisation. NSW can reasonably expect to have similar benefits.

f) *Reduce extra cost with the car dependence*: Car dependence is costly when associated with environmental, social and economic externalities. McGlynn and Andrews[10] suggest an extra 20c savings per passenger kilometre by using the public transit system such as electric rail systems with development built around stations.

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[3] BITRE (Bureau of Infrastructure, Transport, and Regional Economics) (2007), *Estimating urban traffic and congestion cost trends for Australian cities*, Working paper 71, BTRE, Canberra ACT

[4] House of Representatives 2005, *Sustainable Cities*, Commonwealth of Australia, Canberra.

[5] Newman, P. (2007), Planning for Transit Oriented Development in Australian Cities, BEDP Environment Design Guide.

[6] Kenworthy, Jeffrey R., Laube, Felix B. (1999), Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy, Transportation Research Part A, 33, pages: 691-723.

[7] Vuchic, Vukan R. (2005) *Urban Transit: Operations, Planning and Economics*, Wiley Knowledge for Generations.

[8] Curtis,C., Renne, J.L., Bertolini, L. (2009), *Transit Oriented Developments: Making it happen*, Ashgate Publishing Limited.

[9] Cervero, R. (2003) _, Transit Oriented Development in America: Experiences, Challenges and Prospects, Transportation Research Board, National Research Council, Washington DC, USA.

[10] McGlynn, G, Andrews, J (1991), *The economic cost benefits of urban scenarios that support ESD*, Australian Commission for the Future, Melbourne.

2: Framework for managing land use in rail corridors and air space above stations

Creating a vibrant, relatively dense and pedestrianised mixed-use development precinct, featuring quality public space and immediate access to high-frequency public transit are among the aspirations[11] which major economies in the world are adopting as principles for integrated land use planning along with better transit system. US, cities such as Arlington in Virginia, Dallas in Texas, Atlanta in Georgia and San Jose and San Diego in California have benefitted by such projects.[12] Central and western Europe, with transit-rich city centres have also observed successful precinct development. As have Adelaide, Perth, and Brisbane. Success is attributed to:

a) *Rapid transit system*: High frequency, high capacity rapid public transit such as light rail transit, high speed heavy rail; linking the various major precinct to the wider metropolitan area and providing good access is identified by many researchers and practitioners as the key to success. [13] [14] [15]
b) *Mixed-use development:* The precincts to be built around rail corridors and rail stations must provide space for offices and workplaces, which provides a support base of customers. Further, residential accommodation provides additional patrons – who hold a stake in the liveability of the precinct [16]; PATREC 2007).
c) *Optimum public space provision:* Public space should be optimally allocated so that while being generous it should never be too large that the space becomes empty.[17]

Rapid transit between centres and precincts is identified by many as a key strategy for successful projects.[18] Transit coverage across region and better connectivity between origin and destination is linked to potential ridership via public transport. Vuchic [19] also lists key attributes for transit systems such as: area coverage, operating speed, directness of travel and connectivity.

The rising cost of road congestion and the associated inconvenience have posed challenges to major cities worldwide as they struggle to provide efficient ways to transport an increasingly mobile population. Ever increasing oil prices and efforts to reduce carbon emission have added to the pressure to build better public transit systems and to reduce car based travel. Sydney is also grappling with challenges to improve the public transit system

[11] Hale, Chris and Charles, Phil (2006). *Making the most of transit oriented development opportunities*. In: ATRF Conference Manager, Proceedings of the 29th Australasian Transport Research Forum 2006 (ATRF06). 29th Australasian Transport Research Forum, Gold Coast, Queensland, (1-19). 27 - 29 September, 2006.
[12] Dittmar, H and Ohland, G (2004) *The New Transit Town Washington*, D.D: Island Press.
[13] Hale, Chris and Charles, Phil (2006) *et al.*
[14] TRB (2009), Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions, Transportation Research Board | SPECIAL REPORT 298
[15] Newman, P. (2007), *et al.*
[16] Kathi, Holt-Damant (2005) Emerging futures: rethinking the railway station for transit-oriented development. In Renne, John (Ed.) *Transit Oriented Development: Making It Happen*. Patrec, Curtin Unviersity/Murdoch/UWA/ECU, Fremantle, Western Australia, pp. 1-9.
[17] Hale, Chris and Charles, Phil (2006) *et al.*
[18] Hendricks, S J, Winters, P Wambalaba, F Barbeau, S Catala, M and Thomas, K (2005), *Impacts of Transit Oriented Development on Public Transportation Ridership*, Florida: Centre for Urban Transportation Research.
[19] Vuchic, Vukan R. (2005) *et al.*

such as railways, in order to benefit from the higher energy efficiency of rail which is three times more energy efficient than road for moving freight. [20]

There are challenges in optimising the use of rail networks which in Sydney has to be shared between passenger and freight transportation. It is predicted that rail freight services is set to grow significantly and it is expected to be more than double by 2030. This is mainly attributed to the expected mineral export growth. [21]

This growth will place significant pressure on the running of passenger trains running on shared rail networks. Therefore, importance should be placed on efficient use of rail network or expansion of the current rail networks for passenger and freight transport in any consideration gives to the utilization of rail corridor priority to freight is a consideration.

In order to deal with the challenges in planning and operational aspects of rail networks, increasing importance is being placed on the development of simulation modelling based approaches to minimise the risks in planning and efficient utilisation of rail corridors for passenger and freight transport. [22]; [23]; [24]; [25]; [26] Simulation models of the transit systems are essential to support urban planners to visualise and assess the impact of infrastructure related changes. Rail corridor projects could minimise the risk through simulation and modelling for the long term, in order to avoid difficult-to-correct mistakes in urban planning and to provide a reference framework for planners.

3: Vision for developing air space above and adjacent to rail corridors

Several studies have investigated the relationship between rail based transit systems and housing, liveability, recreational centres, and healthcare services.[27] In Perth, 61% of survey respondents have indicated their preference to live in a precinct or housing in a railway station precinct. In this study, three factors were often highlighted in making the decision to reside in or near stations: i) more affordable housing; ii) proximity to public transport; and, iii) proximity to shops and services. Considering these challenges, a set of guidelines are suggested for successful planning and implementing of rail corridor projects:

1. *Station Area Planning*: Use of zoning and land development techniques, including infill and redevelopment, to create higher density mixed-uses around committed transit stations and to give priority to rapid transit projects where local conditions encourage transit supportive development patterns.

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[20] AGO (2002), National Greenhouse Gas Inventory 2000 with Methodology Supplements 1990, 1995 and 2002, Australian Greenhouse Office, Canberra

[21] BITRE (Bureau of Infrastructure, Transport, and Regional Economics) (2009), *Road and rail freight: competitors or complements?*, Information Sheet 34

[22] Cordeau, J.-F., Toth, P., Vigo, D. (1998) *A survey of optimisation models for train routing and scheduling*, Transportation Science, 32 (4) 380-404.

[23] Lewellen, M., Tumay, K. (1998) *Network simulation of a major railroad.* In WSC '98, Proceedings of 1998 Winter Simulation Conference (Edited by D. J. Medeiros *et al.*), pp. 1135-1138, SCS. Washington DC.

[24] Törnquist, J. (2003) Computer-based decision support for railway traffic scheduling and dispatching: A review of models and algorithms, Proceedings of ATMOS2005.

[25] Lusby, R. M., Larsen, J., Ehrgott, M., & Ryan, D. (2009), *Railway track allocation: models and methods*. OR Spectrum, 33(4), 843-883.

[26] Macharis, C. (2004). *Opportunities for OR in intermodal freight transport research: A review*. European Journal of Operational Research, 153(2), 400-416.

[27] Kathi, Holt-Damant (2005) *et al.*

2. *Development of Rapid Transit System*: Plan and design high quality transit system with frequent connections to the CBD and other regional centres. Improved transit system will encourage community development by connecting transit to the community. Locations which have potential for densities sufficient to support rapid transit service should be given early consideration.
3. *Plan for a Mix of Uses*: Mixed use development along the line (residential, shopping, work, leisure) helps reduce automobile use and increases walking and public transit use. Mixed use of the corridor for other infrastructure such as water, gas, electricity and telecoms also warrants serious consideration in reducing infrastructure land demand.
4. *Link development to Community Liveability*: For most communities, a successful transport strategy and a successful community liveability strategy are one and the same.
5. *Pedestrian-Friendly Projects*: Focus on pedestrian-friendly projects to avoid the complication of sequencing development with new transit facilities.
6. *Increase Density*: Density makes a difference in travel behaviour, establishing minimum densities and raising maximums are considerations for planners in developing effective strategies.

According to the Crossrail project in London (major cross-London rail link project), the main strategies for its potential success were (Regeneris Consulting Report):

- To identify areas across London which can provide significant opportunity of growth,
- To identify rail stations with the capacity for sustained growth,
- To consider the benefits that a new station and increased connectivity can deliver to a locality and how participation in the local opportunity can be maximised.

A study in Hong Kong, which looked into the outcomes of Mass Transit Rail (MTR) based integrated rail-property development projects, reported the following results:

- Over 41% of the total population in Hong Kong and over 41% of the territory total workers live within 500 m of an MTR station,
- MTR takes up a market share of over 24% of the total public transport ridership,
- MTR provides a major transport function for the working population during the morning peak hours by connecting the housing areas with the employment districts.

These two examples perhaps provide some guide and aspirations to be considered for planners when reviewing the utilization of rail corridors.

Easing how people can use public transport through developing a high degree of connectivity, as has been achieved in Hong Kong, leads to a greater use of public transport.

Systems such as the MTR provide environments that not only cater for travellers needs in getting from A to B but enhance that experience through the provision of modern attractive and convenient facilities. Through responding to the demands of passengers for retail at the Hong Kong stations they have been transformed from traditional limited convenience

outlets to the creation of modern vibrant and popular retail zones supplying a broad range of goods and services to the traveller. You can visit a doctor or a nail boutique, shop for clothing or stop for a coffee in modern and bright surroundings throughout the day. A total service concept has been adopted in Hong Kong where the Railway and railway staff are focussed on lifestyle needs of the people they serve and their stations and culture have evolved to reflect this.

Corridor development should look to link residence and place of employment more effectively with each development proposal.

In order to better plan for integrated land use and transport, agent based simulation models are an important new approach to understanding old and enduring problems. These integrated land-use and transportation models are suitable tools to support policy decision making (Borning *et al.*, 2008). They have been used to explore a variety of scenarios including urban growth boundaries and TODs.[28]

The modelling approach often used is "agent-based modelling".[29] This represents individuals and their decision making, in contrast to aggregate models that represent whole groups of people at a time. This type of modelling is ideal for examining the heterogenous nature of both the urban environment and people's responses to it, and this form of modelling supports "what if?" exploration of different scenarios. Output from agent based modelling can show not only changes in transport and land use patterns around rail corridors but can illustrate the human reasoning that underpins the different outcomes. For example, not only can we explore the numbers that adopt lower carbon travel profiles, but we can look at their reasoning as to why they changed their travel profile and how that relates to the nature of the development proposal.

At SMART we are currently developing an integrated land use and transportation modelling platform for Transport for NSW, with a focus on liveability as both a driver and outcome of changes in transportation and land use, including rail and infrastructure corridor development. Outputs from the model will include summary text looking at outcomes of different policies and why they occurred in the model, in addition to graphs, tables and maps of outputs, all of which are of value to decision making.

4: Funding and Financing for Corridor Development

Infrastructure funding is one of the key challenges in the implementation of any corridor development. Funding is required for planning, land acquisition, infrastructure, construction and maintenance of corridor development projects. Our experience is that transport related funding for rail based transit system developments have floundered while road developments have flourished. In Australia, $43 billion went to road developments as compared to $1 billion to rail developments during 1974 – 2000 period.[30] Perth saw the

[28] Waddell, P. (2002) *UrbanSim: Modeling Urban Development for Land Use, Transportation and Environmental Planning.* Journal of the American Planning Association, Vol. 68 No. 3, 2002, pp. 297-314.
[29] North, M. and Macal, C. (2005) *Tutorial on agent-based modeling and simulation*, Proc. Winter Simulation Conference.
[30] Laird, P, Newman, P, Kenworthy, J, Bachels, M (2001), *Back on Track: Rethinking Australian and New Zealand Transport Policy*, University of NSW Press, Sydney.

development of new rail in this period and Brisbane established electric rail by a Federal grant. These were the only significant ventures by federal transport into rail. However, this period saw major developments in expansion of road networks that increased urban sprawl and dependence on cars. This is often regarded as a centrist road planning approach where all the funding for transport developments comes from the federal government.[31] In another approach, where Federal government's funding to Australian cities stopped, a market process was thus encouraged by the states using private capital and toll roads. All the major Australian cities including Sydney are moving towards tollways with the exception of Perth. Developments of rail precincts through forms of market based financing have been limited in Australia although increasingly it is recognised that value uplift can be obtained from such development. Although market based financing has seen limited application in Australia, this report encourages its use as increasingly it is accepted that rail developments lead to land value uplift. There are examples of part private funding such as Sydney's light rail and Melbourne's rail stations.

There is an argument that the property value uplift caused by transit construction should come to be seen as a mechanism for partially self-funding infrastructure investment. A case study of Butler-Brighton in Western Australia is cited by Curtis & James[32] report that an integrated land-development and rail infrastructure project, where after taking account of non-ticket revenues reported that - *The estimated financial benefit for the state was envisaged to offset a major portion of capital cost to construct the railway.*

Studies have shown that access to major rail stations has contributed to an increase in housing prices in areas adjacent to train stations. In Amsterdam, a study reported that dwellings very close to a rail station are on average about 25% more expensive than dwellings at a distance of 15 kilometres or more. A doubling of transit frequency leads to an increase of house values of about 2.5%, ranging from 3.5% for houses close to the station to 1.3% for houses far away.[33]

Another case study in London studied the effects of distance from the nearest rail station on house prices, which suggests that rail access is significantly valued by households and that these valuations are sizeable as compared to the valuations of other local amenities and services.[34]

We conclude therefore rapid rail transit will significantly improve the accessibility of the land around the stations and hence increase its values. Proximity therefore to rail corridors can give rise to value uplift which in turn can contribute to development projects of the urban fabric and the transit system.

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[31] Newman, P. (2007), *et al.*

[32] Curtis, C and James, B (2004), An Institutional Model for Land Use and Transport Integration Urban Policy and Research – Volume 22, Number 3, 277 - 297

[33] Debrezion, Ghebreegziabiher, Pels, Eric (2006). The Impact of Rail Transport on Real Estate Prices: An Empirical Analysis of the Dutch Housing Markets.

[34] Gibbons, S., & Machin, S. (2004). Valuing Rail Access Using Transport Innovations.

5: Case studies related to the use of air space above and land adjacent to rail corridors

The following are case studies from cities from Australia, Europe, and US; which highlights the benefits from developments associated with rail corridors.

Stockholm, Sweden

The policy of creating highly dense centres and developments around rail stations radiating out from the city in Stockholm provides an excellent example for integrated transport and land use activity. The main characteristics of these centres as illustrated by Newman and Kenworthy[35] are: employment close to residential dwellings; personal services that are easily accessible; shops close to residential areas; residential density higher near stations then radiating out: all multi-occupancy units, etc, within 500 metres of a rail station; all family dwellings within 300 metres of a bus stop; a bus-rail interchange in all centres; and a good network of pedestrian and cycle ways within and between centres.

During 1980's, public transit based trips rose from 302 to 348 per person. This growth of public transit as preferred modal choice is attributed to developments around transit stations that promote higher density and pedestrian movement. This has achieved one of the highest transit levels in the world.

Naples, Italy

In Naples, the Regional Metro System (RMS) project started in 1996 which integrates the existing lines into a single network by building new interconnecting lines, new stations, new modal exchange facilities. The main characteristics of this project are: high frequencies for rail services; connections between different lines; integration with land use policies; urban renewal for new stations. The expected outcome of this project is predicted with the help of simulation models of transportation for Campania region. According to the model, modal share of public transportation will increase from 40 to 60 percent and the number of passenger kilometres will increase by 110 percent on railways and by 11 percent on buses.

Perth, Australia

Perth adopted a new planning strategy, Network City (WAPC. 2004), which is focussed on integration of land use and public transport networks. The Network City's framework is based on three main elements. Activity corridors are centred on either a main arterial road or suburban railway line (400 m on either side), activity centres are developed at the intervals along the activity corridor (focusing on daily activity needs – employment, shopping and services, and dense housing) all placed within walking distance of the public transport node at the centre. Transport corridors are paired with one or more activity corridors to form a network, and provide a fast moving route for inter-urban travel.

[35] Newman P. and Kenworthy J. (1992) Transit-Oriented Urban Villages: Design Solution for the 90's, Urban futures Journal, Vol 2, No 1, pp50-57

Further, in a specific study, Subi Centro in Perth saw a model transit oriented development implementation from 1997 onwards. The redevelopment of former industrial land in Subiaco provides a mix of medium to high density housing, offices, shopping and services, together with an excellent public access to a new underground station. The underground station precinct (on land above and adjacent to the new underground railway station) is the key aspect of Subi Centro redevelopment project.

Arlington, US

The Rosslyn Ballston corridor in Arlington, in Virginia (US), saw major developments around transit nodes, which provided benefit to both new and existing residents. It was a declining low density commercial corridor three decades ago, when local government decided to develop area around and above five rail stations, working with residents and the private sector. There has been a small increase in traffic against development surrounding these stations. The following are some of the outcomes:

- value of land around station increased 81 percent in 10 years,
- 8 percent of county land generates 33 percent of county revenue,
- 50 percent of residents take transit to work; 73 percent walk to stations.

Singapore

The constellation plan of Singapore is a good model of development, which focuses on compact, mixed-use new towns around many suburban rail stations. It successfully integrated the mass rapid transit with the regional developments following Scandinavian planning principles of radial corridors that interconnect central core with new suburban towns. The towns are interconnected with high-capacity, high-performance rail transit. As a result of this plan, its vehicle kilometre travel per capital is lower than any urbanised region in world with GDRP over US$10000 and high public transit trips (480 annual trips per capita in 2002).

6: Opportunities and implications for New South Wales

In the foregoing there are examples of good outcomes associated with rail corridor planning and management, rail stations and rail land development, both within Australia and around the world, while every city presents a unique environment opportunities do exist to be harnessed in NSW.

A high quality transit system with regular service connections to the CBD and other centres is required, which will require:

    - Efficient utilisation of existing rail corridors; and,
    - Extensions in rail corridors to accommodate ever increasing demands for freight and passenger transport
- Smart planning (integration of land use and public transport) based on modelling and simulation is required for evaluating future scenarios. Following types of

simulation modelling can help to improve existing infrastructures and planning for future developments:

  - Integrated transport and land use simulation - this will model different modal choices such as private cars, buses, trains, others with the land use plans. The resulting simulation models can help to identify interactions between people modal choices and land use planning, which will be useful for future integrated planning projects,
  - Rail logistics modelling - this will model the railway networks and simulate the train movements to optimise overall productivity of rail corridors and its utilisation.

- New rail project for rail based public transit has huge potential in NSW with the increasing population and increasing freight rail logistics.
- Private and public funding mechanisms are required for improving/developing rail based transit and areas around rail corridor in NSW. Following are the few potential suggestions for public and private funding partnerships NSW (as suggested in Newman[36]):

  - Proposal for a Western Sydney Fast passenger rail systems that is entirely privately funded based on the tollway finances,
  - Development levy on the new blocks in the Southwest Land release area can induce significant funding for rail project financing,
  - Light rail consortium to finance the extension of LRT (light rail transit) through land development mechanism, this will require public and private partnerships.

All the above mentioned scenarios and issues can be explicitly modelled and potential impact can be analysed.

Critical infrastructures such as rail, electricity and gas, water, other involve multi-dimensional complex collections of technologies, processes, interactions, and as such are vulnerable to potentially failures. Cross-infrastructure dependencies can give rise to cascading and escalating failures across multiple infrastructures. In order to address this problem, an advanced simulation and data modelling based research methodologies are needed. SMART along with other collaborating institutions have the platforms and research base to allow us to address these issues.

[36] Newman, P. (2007), *et al.*

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