The Power of Integrated Spatial Modelling: RailSmart Planning Wanneroo

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Abstract: The Planning and Transport Research Centre has just completed a major Smart Cities project entitled "RailSmart Planning Wanneroo". The output was an interactive digital platform which tests optimal public transport patronage and employment creation potential of various railway station development options. The process of formulating the system was fascinating as this paper will argue that the concept of modelling intrinsic within the Smart Cities concept is a return to 1950's procedural planning policies such as mixed method planning and a bounded rationality. The project highlighted the danger of entrenching existing patterns if systems are fully automated and argues that the power in the smart modelling should be limited to informing scenarios to best test alternatives. The power of the dashboard does not lie in the results it generates but rather in the patterns and trends it displays. The paper begins by describing the project and its outputs this is followed by a deeper reflection on how this was achieved procedurally. The process of creating this dashboard laid bare the dilemmas of planning where planners serve more than one client as they are working for a client in the public realm and within a political reality.

Key words: Spatial, forecasting, scenarios, employment, patronage

Introduction

In May 2019, the Planning and Transport Research Centre (PATREC) was awarded an Australian Government Smart Cities and Suburbs program grant for a proposal called "RailSmart Planning Wanneroo". The brief was to create a digital dashboard to calculate job creation potential and public transport patronage related to the building of a new heavy railway extension from Butler to Yanchep, near the northern boundary of metropolitan Perth. The proposal was that PATREC would apply analytical tools, which the team had previously created, to the planning of the three new stations in the City of Wanneroo, with a view to forecasting public transport patronage numbers and to better inform employment creation. The tools which existed were academic in nature and had not previously been rigorously applied. The first tool was a station analysis in terms of place, node and background traffic (Olaru *et al,* 2017); the second tool analysed patterns of public transport use via the automatic ticketing system data (Cardell-Oliver *et al*, 2017); the third tool looked at accessibility via public and private transport (Sun *et al,* 2017); and the fourth tool analysed employment (Martinus and Biermann, 2018). The tools were augmented with a survey on the potential uptake of ride sharing options to feed the stations (Standing et al, 2019).

The Smart Cities concept is a topical issue, but remains a vast and ill-defined field. Even so, most people can intuitively see the value in using information and technology to aid in planning and managing cities. As Kitchin, et al. (2018, p.1) state "many cities around the world are presently pursuing a smart cities agenda in which networked information and communication technologies are positioned and utilized to try to solve urban issues, drive local and regional economies, and foster civic initiatives". The Smart Cities concept "…combines, builds on, and extends earlier paradigms such as digital city, virtual city, ubiquitous city, intelligent city, creative city, knowledge city, hybrid city, information city, and wired city. With the evolution of the smart city concept over the past decades, there has been a paradigm shift from an initially technology-driven focus (with high emphasis on ICT) that is aimed at maximizing efficiency of the hard urban infrastructure (i.e., transport, communications, waste, energy, water, etc.) to adopting a more comprehensive approach, wherein the central role of people and the soft infrastructure (i.e., institutions, citizen engagement, data, social innovation, knowledge economy, justice, etc.) is acknowledged. By integrating multiple dimensions, smart cities intend to function as agents of strategic transformation and provide resources and pathways for increasing operational efficiency, competitiveness, and QOL, and for approaching sustainability" (Sharifi, 2019,p 1270). These are lofty goals; this paper seeks to reflect on the process used to build the dashboard. How did the project team produce an integrated analytical platform based on four discrete analytical tools? What lessons can be learnt and applied more generally when integrating data as part of the "Smart Cities" movement?

The paper will begin by presenting the RailSmart dashboard with specific reference to the approach(es) adopted in its production; this is followed by reflections on the Smart Cities concept, with specific reference to the lessons learnt creating the RailSmart dashboard.

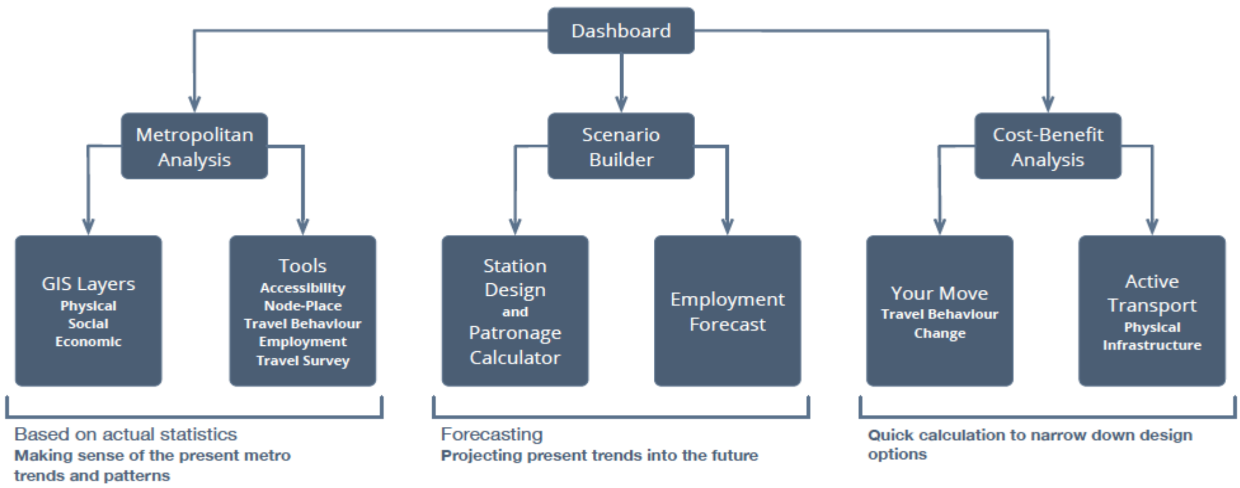
RailSmart Planning Wanneroo

The RailSmart dashboard was developed as a proof-of-concept planning support system. It seeks to demonstrate that academic research can be applied, integrated and disseminated so as to better inform public decision making. This case study allows for testing future development scenarios in terms of employment creation and public transport patronage. The system applies advanced modelling, which had been developed in academia and integrated the outcomes to better inform the development around three new railway stations in the local government area of Wanneroo in the Perth metropolitan area. The City of Wanneroo specifically wished to develop the new areas in a manner in which they could maximize the use of public transport and to reach a 60% employment self-sufficiency target. In addition, the Western Australian Department of Transport wished to implement a Cost-Benefit Analysis tool based on the Australian Transport Assessment and Planning (ATAP) guidelines, which has also been included in the system.

The Dashboard was developed by a large interdisciplinary and multi-agency research team managed by PATREC.

The dashboard is divided into three sections – metropolitan analysis; scenario builder; and, cost-benefit analysis – which are outlined in Figure 1 below:

Figure 1. Component Diagram of the RailSmart Dashboard



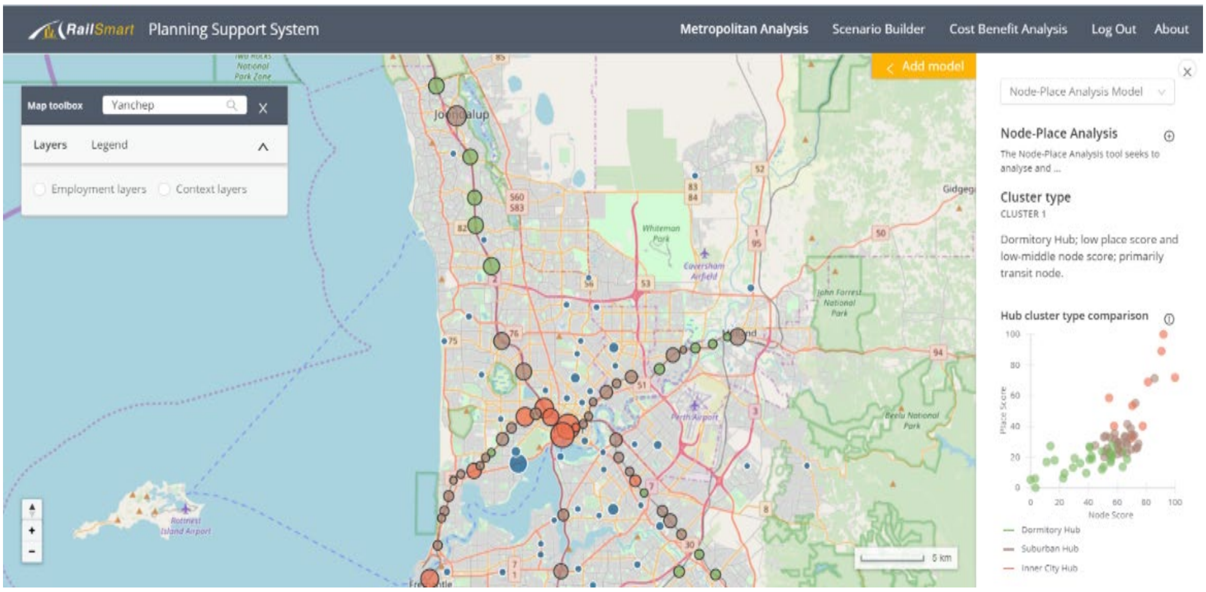
Source: Authors

Metropolitan Analysis

The metropolitan analysis section consists of a rigorous analysis of metropolitan Perth through the application of research tools described below, and a series of GIS analytical layers which spatially represent social, demographic, economic and physical information.

The metropolitan analysis was completed in order to list the design parameters and calculate the patronage of all existing railway stations in the Perth metropolitan area. The results of this analysis are presented as a web-based dashboard. The metropolitan analysis feeds into and informs the scenario builder. It consists of four tools, the analysis of a survey and GIS context layers. A screenshot is shown below in Figure 2 which details the components of Tool 1, which will be explained in the next section.

Figure 2. Screenshot of Tool 1



Source: Authors

Tool 1: Activity centre node-place analysis and activation tool

The core of the project is built around the analysis of metropolitan Perth's existing railway stations. Tool 1 gives a detailed analysis of the railway station precincts with respect to their *Place*, *Node*, and *Background Traffic* characteristics. The place analysis looks at the quality and vibrancy of the built environment around a station. Node is defined as the transport characteristics of the station area - the throughput of passengers, alighting's and boarding's. Background Traffic refers to the accessibility to the station via both public and private transport, aside from the railway line itself, such as through feeder buses and taxis.

Thus, the Node/Place/Background Traffic analysis is assessing the station in terms of its functionality moving people through the system (node), the function as a place where people meet and greet, shop, and work (the place function) and how accessible the station is to other major land uses (what can you reach within a given time from the station?). These are weighted and ranked so that all stations can be compared and contrasted based on standardised measurements.

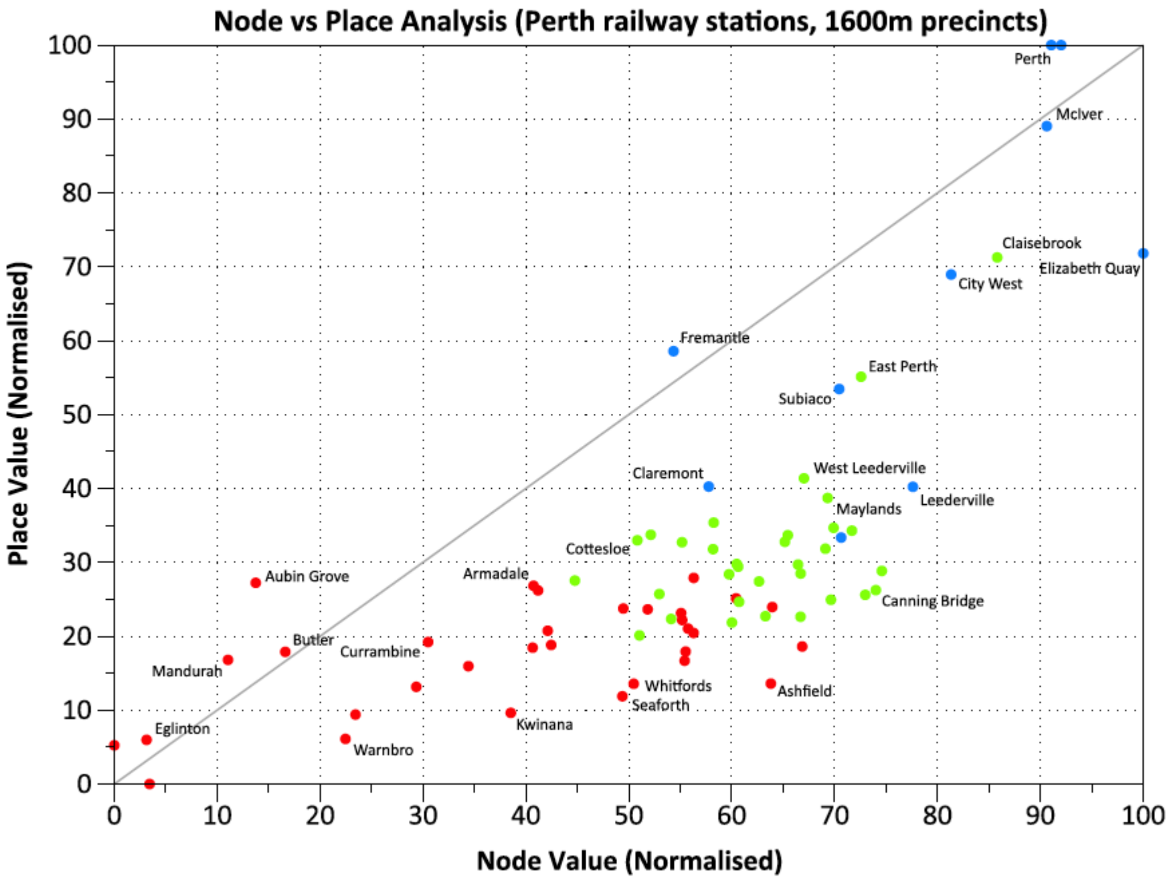
The tool works via a two-stage analytical process:

- Cluster analysis – categorising the stations into groups with similar Place, Node, and Background Traffic characteristics; profiling the clusters and classifying the train station precincts by allocating them to the most likely cluster based on their similarities and dissimilarities with the other station locations.

- Regression analysis – 'producing equations' to predict station boarding's/patronage based on key station and catchment characteristics. The analysis identifies patterns which are common to various station types and thus, you can assume if you are planning a station which is similar to one of the existing stations then it will share similar Place, Node, and Background Traffic, which in turn become predictors (explanatory elements) of the patronage and mode choice.

Figure 3 below is a graph plot of all of the Greater Perth stations; it indicates that very few stations in Perth have a high place value. Perth is in essence a mono-centric city with the CBD (the two data points –Perth and Perth underground- on the 100 Place line) by far the most diverse. Three categories emerge Dormitory hubs (red); Suburban hubs (green) and Inner city hubs (blue).

Figure 3. Graph Plot of Node vs Place Value for Perth railway station 1600m precincts



Source: Authors (A full academic explanation of the research, the list of authors of the work and all of the components of the analysis is available in Olaru et al (2017)).

Tool 2: Railway Usage Analysis and Travel Behaviour[1]

The second tool is an evidence-based, data-driven tool centred on the analysis of SmartRider data. It uses data gathered by the electronic ticketing system of the public transport system in Perth and can infer when passengers board or alight a bus or train. While Tool 1 examines transportation from the point of view of the built form, Tool 2 does the opposite; it analyses the way people move through the system. The two tools together give a very powerful understanding of public transport, land use and the manner in which they interact. When the SmartRider data was analysed, it became evident that there were patterns which were easy to explain in the time between when a passenger leaves and re-enters the system. Such patterns are a gap between 9am – 3pm (corresponding with attendance at school), 9am – 5pm (work) and 5pm to 8am (home); this is extremely useful as it tells us about the land uses around the station and the relative public transportation usage. As this analysis covered all the bus stops as well as the rail system it highlighted groups of bus stops with similar usage patterns, these were grouped into geographic hubs. Key hubs emerged around private high schools, universities and hospitals which highlights the functions which attract public transport usage.

Tool 3: Enhanced Employment Self Sufficiency Tool[2]

Maximising employment potential is one of the major aims of this project; the City of Wanneroo has a target of creating 100,000 new jobs over 20 years in order to reach the state target of a 60% jobs housing balance. This poses a question of where a local government should start when calculating employment and attempting to create new jobs. Not all employment creation happens in the same manner; there are a number of jobs across a range of skill levels which naturally occur once the

[1] This is further explored by the authors of this analysis in Cardell-Oliver et al (2017).
[2] This analysis is an extension of work which has previously been completed by Martinus and Biermann (2018).

population grows and creates the demand for services. Jobs such as doctors, teachers and shop assistants naturally form once the population demand exists. Other jobs are created due to a competitive advantage and are more strategic in nature - for example, gold mining occurs where gold is discovered or the computer industry evolves where there is a concentration of high-level computer skills.

Tool 3 begins by categorizing all of the Australian Bureau of Statistics (ABS) occupation categories into either “strategic employment” or “population following employment” for each Statistical Area, Level 2 (SA2). The dashboard then determines the proportions for the local government area (LGA). A local government area’s strategic advantage(s) is calculated by means of Location Quotients, using Perth, Western Australia and Australia as analytical bases. National multiplier effects of each employment category are applied to calculate the knock-on effect of strategic job creation. These two key data sets work with the clearly reported stratification of the aforementioned ABS data into “strategic” and “population following” employment sets. The strength of this tool is that it allows local government areas to focus their employment creation by removing consideration of the jobs which will simply occur (those which are “population following”) and focusing instead on the key strategic jobs based on the areas competitive advantage. A local government thus focuses on providing the land, services and infrastructure to support key industries which can best create the employment required.

Tool 4: Dynamic Accessibility Planning Tool[3]

Accessibility, as it relates to urban and transport planning, measures the ease with which individuals are able to access their most important activities. The tool calculates accessibility from any of the stations to the centre point of all STEM zones (derived from the Department of Transport’s Strategic Transport Evaluation Model) to be able to map what is accessible via either public or private transport. In this case accessibility to ‘what?’ is important; the tool measures accessibility to jobs, houses and population.

Last Mile Survey[4]

A survey was conducted to identify households and citizens with a propensity to adopt sharing economy transport options. This is part of a wider “last mile” transport problem; that is, the problem of connecting suburban areas to stations. Suburban areas are characterised by low housing and population density and cover large areas meaning that most bus routes are very long and ridership numbers are low. The tool offers insights into the factors that determine a person’s propensity to use and adopt sharing economy transport options, including commercial ride sharing (Uber), community car-pooling, bike sharing, and car sharing as a potential alternative to public and private transport.

GIS Context layers

The purpose of the GIS Layers is to provide spatial analysis of sub-regions of the Perth metropolitan area, which can be used in tandem with the other models, tools and analyses to determine spatial correlations between the two. While some GIS layers were purely descriptive, others contained demographic analysis using data from the ABS.

The Scenario Builder

The scenario builder section of the dashboard is fundamentally different from the metropolitan analysis and has thus deliberately been kept separate to avoid any confusion. Whereas the metropolitan analysis is based on actual data and observed trends, the scenario builder is future-orientated and based on projections; stated another way, the metropolitan analysis is factual and historic (in the sense that it is only as new as the latest census or other data sets) whereas the scenario builder is anticipating and forecasting the future. The value of the scenario builder lies in broad trends; the actual values reported are indicative based on trends analysis. The system allows for the testing of different development options so that different strategies can be compared and contrasted in order to achieve optimal outcomes. The scenario builder directly answers the brief of how to determine optimal employment numbers and how to maximize public transport patronage. In this proof-of-concept, the tool uses the case study of the local government area of Wanneroo, which is coincident with the northern boundary of metropolitan Perth. A railway line extension with three new stations is being developed in the LGA and the LGA would like to use the opportunity to create employment hubs and thereby also maximise

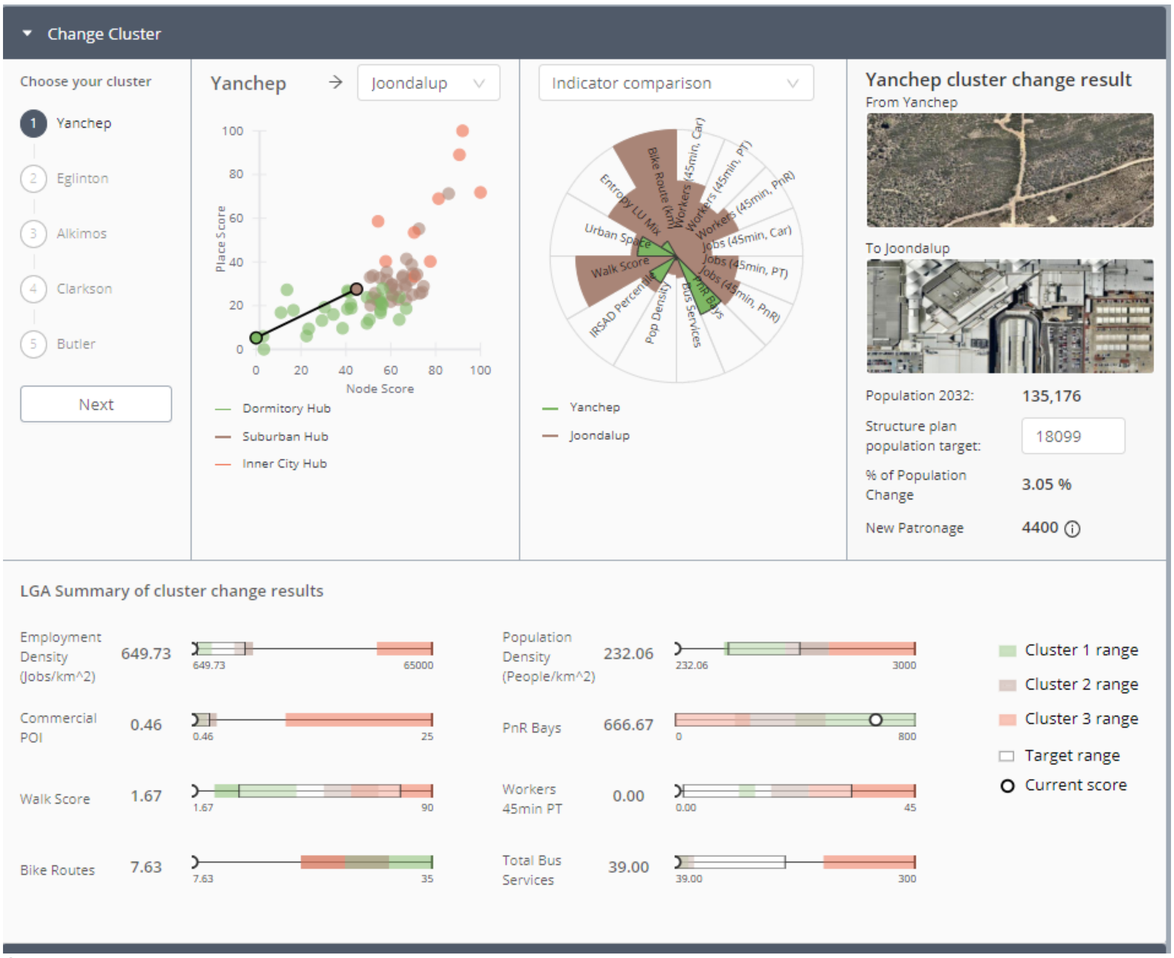
[3] This analysis is an extension of work which has previously been completed by Sun et al (2017).

[4] This survey is reported in Standing, C. Standing, S, Jie, F. (2019) RailSmart Survey on Transport Sharing, PATREC technical paper

public transport patronage. The scenario builder uses the population projections from Western Australia Tomorrow to provide a target population.

The existing approved structure plans for the area state that the City would like Yanchep Station to look like Joondalup; Eglinton to look like Butler and Alkimos to look like Warwick. Given that all of these stations have been analysed in the metropolitan analysis, the attribute data, together with population thresholds and patronage numbers, can be fed through into the scenario builder. This in turn gives you all of the design elements required to make this happen, as well as values from of which employment can be modelled. The system allows the user to select any station to compare the new stations with as to ascertain if the structure plan is optimising development. The dashboard tells the user the percentage population increase required in the 1.6km station catchments, above that stated in the structure plan required to achieve the desired outcome. In the case of the three new stations in Wanneroo, even if the same station aspirations are modelled as per the structure plan, it is evident that higher population densities are required around the station than listed in the structure plans. This can be seen in Figure 4 below.

Figure 4. Screenshot of Scenario Planner (Railway Station view)

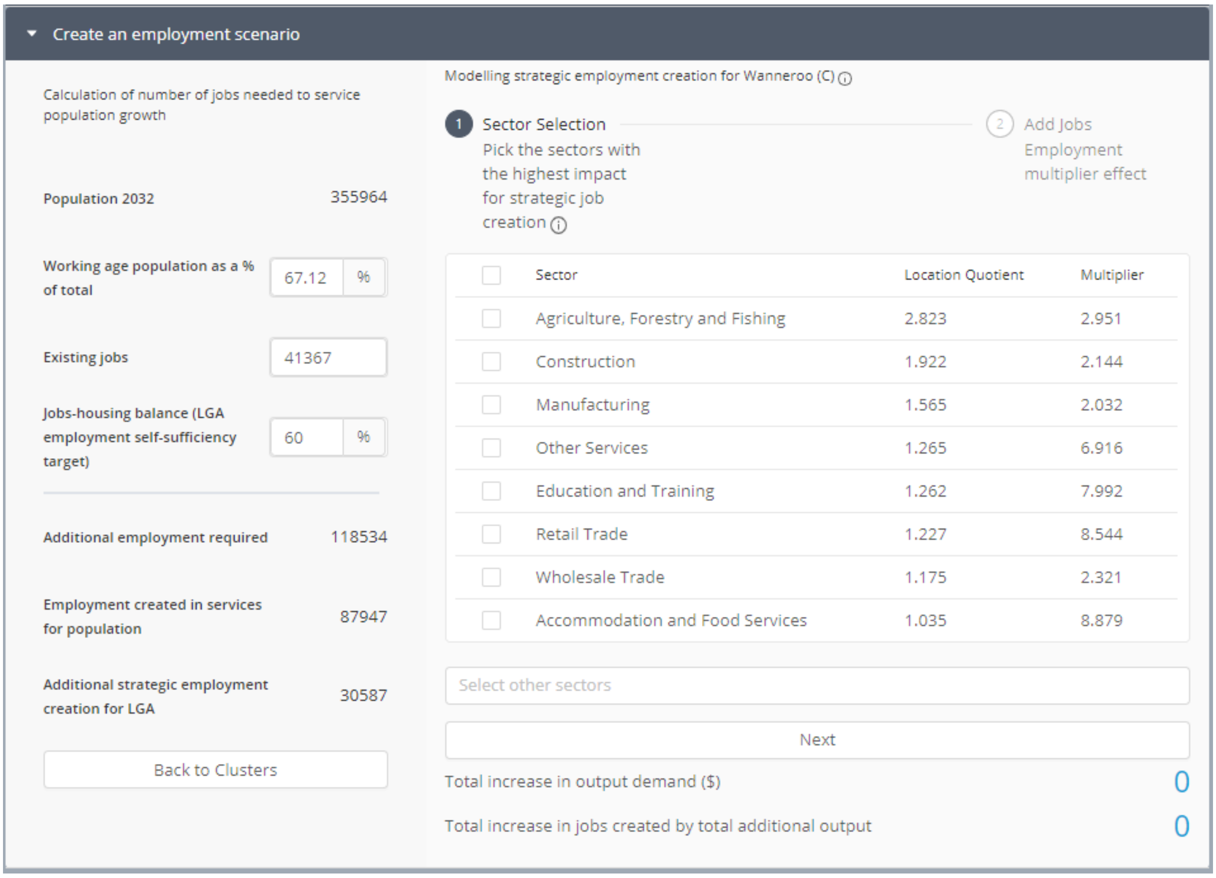


Source: Authors

The second task pane of the tool breaks down the employment; firstly, the population is converted into a required number of jobs by determining the working age population, subtracting existing jobs and applying the jobs/housing balance that the LGA seeks to achieve. The total number of additional jobs required is then split into strategic and population following jobs, based on the existing ratio for the LGAs as of the last census. The breakdown is calculated based on ABS occupations data.

The right hand side of the task pane lists the top location quotients for the LGA, in descending order, along with their multipliers. Employment multipliers are calculated nationally and are based on industry, so these sectors are slightly different from the occupations used to determine strategic and population following jobs. The key issue with employment multipliers is that the location of additional jobs created is unknown, they could be off shore, or in the case study area of Wanneroo, many jobs may have a knock-on effect for the Perth metropolitan area, but not necessarily based in Wanneroo. The more location dependant sectors such as construction, agriculture and mining are most likely to have the full multiplier effect in the same location. The value of this component of the system lies in clarifying where a local government should focus its effort. The City of Wanneroo has a target of creating 100,000 new jobs; this is a daunting target, however, as illustrated in Figure 5 below, 87,000 jobs will naturally occur as the population grows to service their needs. Planners already know how to plan for these jobs, as local planning already supplies area for hospitals, schools, clinics, libraries, shopping centres and so forth where these jobs occur. The local government needs to focus on the 30,000 strategic jobs; yet if you take into account the multiplier effect it becomes an altogether more manageable feat, especially given that the system tells you where your areas' strengths lie. The system can also be used in another way, if, for example, a TAFE college is planning to locate a new campus in Wanneroo, the user can input the number of staff and determine the knock-on employment effect for the area. This can be seen in Figure 5 below.

Figure 5. Screenshot of Scenario Builder (Employment view)

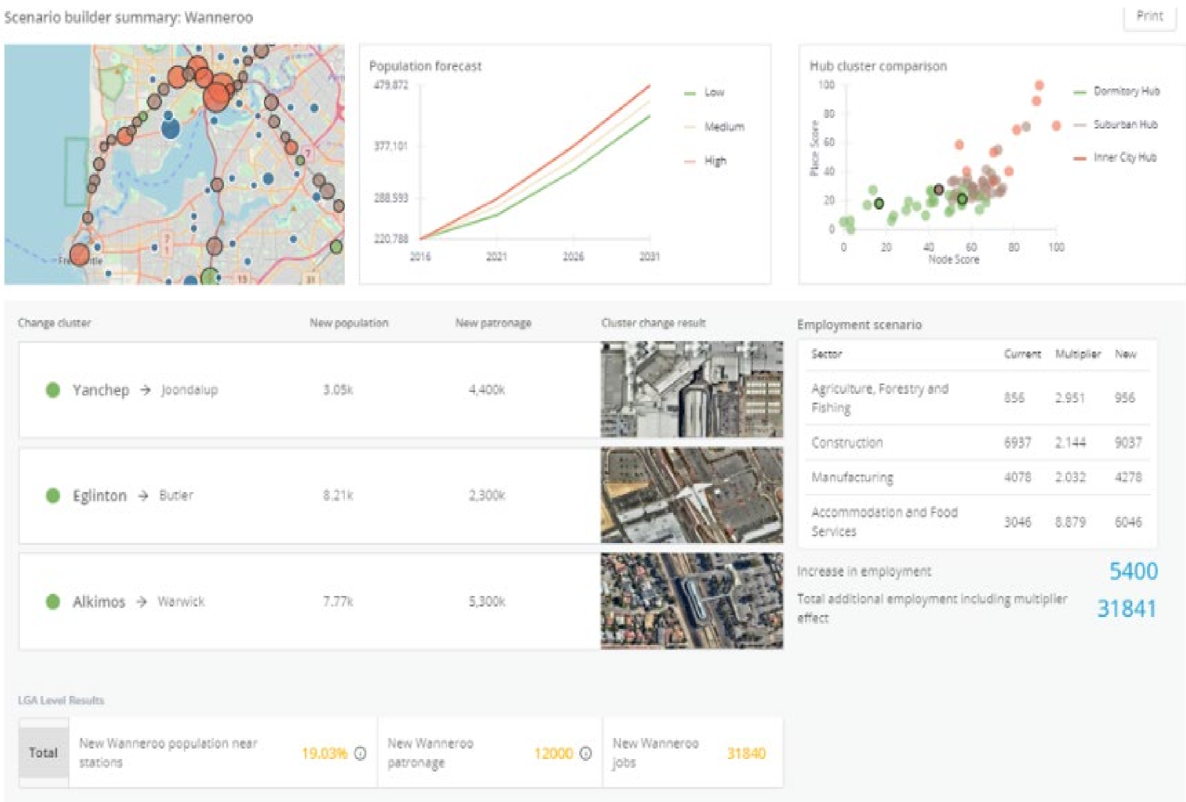


Source: Authors

The power of the system lies in allowing the user to test alternatives. Caution is needed in the use of these values, as the multiplier effect does not mean that the jobs will be in Wanneroo; more fixed location industries such as agriculture are more likely to have the full multiplier effect in Wanneroo compared to, for example, IT jobs which could be international. Some sectors are also time sensitive - for example, the construction industry has a very high LQ in Wanneroo, precisely because it is a newly expanding area; these jobs are unlikely to remain once the area is fully developed.

Each time the user tries something new, they have the option of launching a report to keep track of the alternative solutions. An example of the report can be seen in Figure 6 below.

Figure 6. Example of Printed Report from Scenario Builder



Source: Authors

Cost-Benefit Analysis

The Cost-Benefit Analysis quantifies anticipated benefits such as lowering of pollution, improved health or reduced accidents as economic benefits of a travel behaviour change project. It is an education based programme, providing information and marketing-based approaches. Active travel is any form of travel which requires physical exertion by the traveller - for example, cycling or walking. The tool quantifies the economic impacts using rapid cost-benefit analysis for the purpose of comparing various options.

The Smart Cities movement and RailSmart reflections

The Smart Cities movement seeks to use the wealth of data which is available today in order to solve many of society's problems. The vision is that with better information systems, such as sensors within the transport, water, sewer, postal, telecommunications and similar networks, the networks can be optimised, services streamlined and made bespoke to users' needs. Dodson (2018) clearly expresses his distaste for the idea as a:

> …particularly pernicious variant of neoliberalism […] This movement desires a future in which vast streams of sensor data are fed into wondrous artificial intelligence that beneficently and autonomously monitor and optimise flows of people, vehicles, water, electrons and waste through ubiquitous and seamless urban infrastructures […] Often these involve handing control of key urban functions – transportation, waste management, and community services – to private technology companies who then run the operating systems. The risk of complex, often secret algorithms serving private rather than public interests is yet to be grasped by many governments.
> (Dodson, 2018, p.90)

By taking a step back from considering what the RailSmart platform is, understanding of where (if anywhere) RailSmart fits into urban management can be considered. Questions, such as, "where does it add value" and "where are the limitations" can be answered: By so doing, reflection on the 'smart city' movement more generally can be undertaken to assess its limits, strengths and weakness.

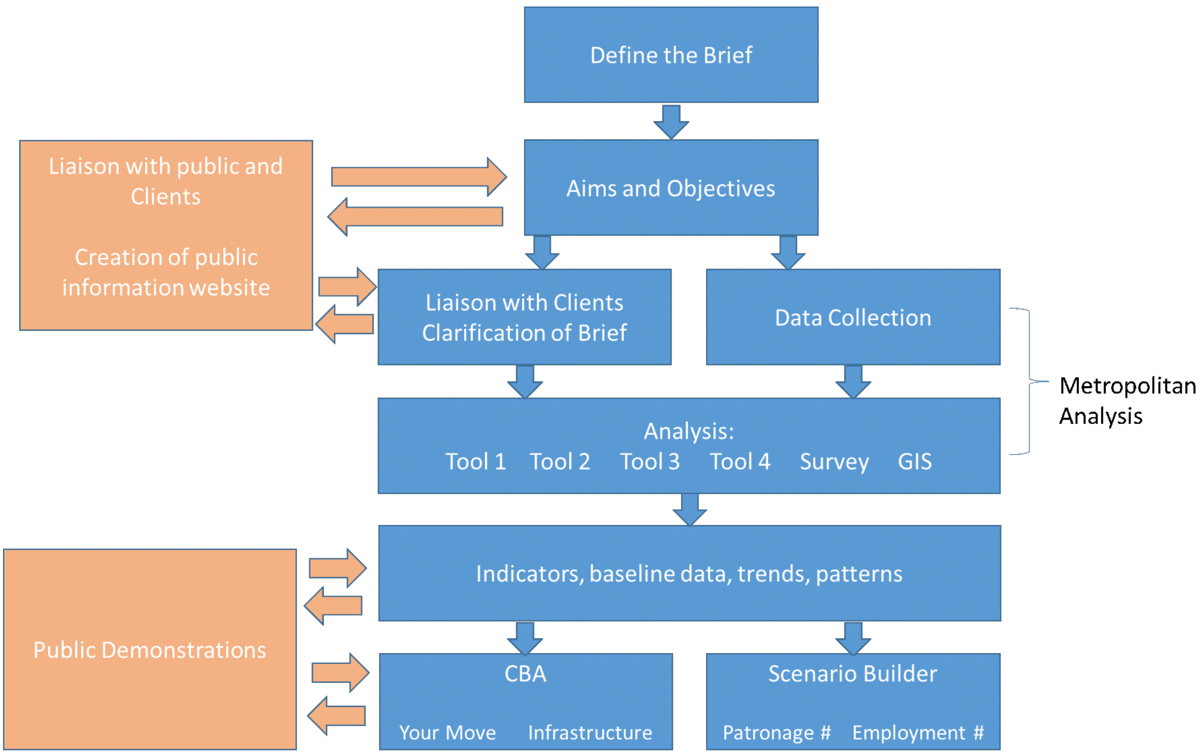
Procedural Approach

The project proposal that was formulated, prior to the first author's involvement as the project manager, was to apply existing tools to test the optimal manner in which to maximise the use of public transport; to reach a 60% jobs/housing balance and to provide a means of running rapid cost-benefit analysis calculations to allow for early project proposal selection and scoping. The first issue is that analytical tools by their nature tend to optimise for one aspect, given that all others are known inputs. Secondly, tools can only ever inform decision making and policy formulation, they cannot by themselves 'optimise' and; thirdly, the idea was to inform future development of what is basically a greenfield site so all of the tools needed baseline input data. The project sought to inform or test assumptions within larger decision-making processes such as the approved structure plans, the approved rail route and the future development of the stations. In short, the project sits within a very much wider decision-making process and on the interface between local government and state government levels.

The starting point was to define the project brief and the aims and objectives, this had already occurred in the project proposal stage and they were thus a given. The project team spent a few months liaising with the clients, unpacking the aims and objectives and gaining clear insight into what was required. Whilst this was happening data collection was underway.

Early on in the project it became obvious from a broad literature review by the lead author that Perth had many unique transportation and land use characteristics and that putting in the heavy rail line ahead of development was unusual. Given this, the direct application of international best practice would yield limited results. To avoid these problems, it was decided to model the new development off of a detailed analysis of the Perth metropolitan transport system. This gave rise to the project being conceived of in two separate elements: the metropolitan analysis as the analytical base and the scenario builder to model future trends. The process adopted is illustrated schematically below in Figure 7; what is striking is the similarity to traditional procedural planning theories, even though the process was adapted to the project at hand. What is unique about the system is that the scenarios are the outcomes of the process, not the inputs into the process.

Figure 7. Schematic Diagram of Process



Source: Authors

The approach is not totally unique' as it leans heavily on the project managers' training as a town planner and is a composition of several procedural planning theories. From the outset, the brief and the aims of RailSmart included value statements, in the sense that maximising public transport is seen to be desirable and that a jobs/housing balance of 60% should be pursued. The cost-benefit analysis is based on the ATAP guidelines which calculate societal benefits from a shift in transport from car to the use of active travel or public transport; the shift is portrayed as desirable, even though is some aspects it may not be, for example there are more cyclist deaths in accidents. Likewise, the Western Australia Tomorrow population projections on which the scenario builder is based also encapsulate a growth view of Perth.

The extension of the heavy rail line itself is a value judgment, brought forward due to the change in state government. The project thus sits within a democratic policy environment, imbued with public statements. As Davidoff and Reiner (1973, p.22) point out, planners have two client groups; the planner's employer and the ultimate clients – those affected by the proposals. Given this problem, RailSmart avoids giving answers – instead, it allows the user to test multiple scenarios in order to arrive at the most appropriate outcome. It was recognised early on in the project that the system informs public policy. The system is careful to limit itself to modelling aspects which can be modelled and to avoid integrating policy statements into the models. The models need to remain neutral.

Conclusion

The RailSmart dashboard offers an example of how four discrete analytical tools, multiple geographic analytical area units (such as STEM zones, SA1, SA2, LGA's) and unpredictable future trends can be merged together to offer spatial patterns and trends analysis which informs urban development and management.

The major problem with the smart cities movement, it is argued, is that it is often seen as an end in itself and by extension it is assumed that optimising flows of people and services is a 'good' thing. It is often said that planning is both an art and a science. There are many aspects of planning which don't lend themselves to pure rationality. Anyone who has driven through Perth's northern suburbs will tell you that functional is not always exciting nor attractive. Place making is an art, where trade-offs are made to reach desired outcomes for a stratified and complicated 'public' – mathematics and modelling can only go so far. In the haste to create smart cities, there is a risk of recreating the planning problems of the 1950's when they produced huge data heavy blue print plans which invariably sat on shelves unimplemented. There is also a real risk of extrapolating and entrenching present imbalances and attitudes. In Perth, for example, the Mitchell Freeway is being widened at the same time as the PTA bemoans the decline in rail passengers – this is perfectly logical, as each organisation optimises their own system; but it is not something society would want to automate and thus, mindlessly project into the future.

The 'smart' in smart cities would be to curtail the influence of these systems to analytical inputs into a larger, more integrated and philosophical process. The RailSmart system attempts to do this by presenting complex information in an accessible manner and by using scenarios to offer multiple outcomes informed by rigorous analysis; in so doing, it lays bare the trade-offs needed to achieve each outcome. This would allow for informed community debate and policy formulation. The system should never be the end in itself.

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