

Sustainable urbanization: four stages of infrastructure planning and progress

Peter Newman

Curtin University Sustainability Policy (CUSP) Institute, Curtin University, Building 209, Bentley, Perth 6845 WA, Australia

Abstract: Urbanization has accelerated in the 20th century. This paper will try to examine the stages we have gone through in this past half century and where we seem to be going on infrastructure planning in this century. It will trace the history of infrastructure planning from the modernist period that began in the 1940's to the postmodernist period from the 1980's, followed by the emerging sustainability period in the early 2000's and now as we face an uncertain future, the disruptive innovation period. The paper emphasizes transport and land use planning along with some consideration of energy, water and waste and uses the dominant planning paradigm of the time to frame the discussion and observe how that has influenced the resulting infrastructure outcomes. Illustrations are used from the author's home town of Perth based on practical experience in the planning system.

Keywords: sustainable urbanization, infrastructure, modernist

Correspondence to: Peter Newman, Curtin University Sustainability Policy (CUSP) Institute, Curtin University, Building 209, Bentley, Perth 6845 WA, Australia; Email: p.newman@curtin.edu.au

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1. Introduction

Urbanization has accelerated in the 20th century so that from 5% of people living in cities in 1900 we reached 50% not long after the end of the century. The current predictions are that there will be 75% of people living in cities across the world in the lifetime of most professionals and planners. This paper will try to examine the stages we have gone through in this past half century and where we seem to be heading on infrastructure planning in this century.

Infrastructure planning is essential for any city. Cities throughout history can be seen to have had planned roads, sewerage and water supply^[1]. Without such planning the city is only informal, i.e., a series of slums, and there were many cities with over 80% in-

formal building that have survived, but with great inequities and huge problems correcting their infrastructure^[2]. Thus, it is efficient and equitable to plan for infrastructure.

The paper will trace the history of infrastructure planning from the modernist period of the 1940's to the postmodernist period of the 1980's, followed by the emerging sustainability period in the early 2000's and now as we face an uncertain future, the disruptive innovation period. This paper will emphasize transport and land use planning along with some consideration of energy, water and waste. I will use the dominant planning paradigm of the time to frame the discussion and observe how that has influenced the resulting infrastructure outcomes. Examples will be used from around the world, including my home town of Perth, which has been planned from 1833.

2. Phase 1: Modernist — 1940's to 1980's

Modernism is the most dominant planning paradigm of the 20th century. Much has been written on this. My perspective in terms of the practice of planning and infrastructure is that it provided a certainty that was based on a semi-scientific approach and for the first time it separated out functions, especially transport and land use. The Athens Conference of CIAM which was essentially the work of Le Corbusier in the 1930's produced the concept of the Functional City with land use for living, working and recreation, separated from transport as a different function^[3]. This set the scene for comprehensive urban planning of the post war period that focused on how to separate out these functions and make each one efficient and sufficient to meet the needs of future urban populations. It is a powerful paradigm that has lasted till this day.

A fundamental tenet of the Modernist city was the commitment to space. No longer did the structures of the industrial city and its tenements hold us back. We could have a 'healthy supply of clean air', a more natural city; the motto of the UK Town and Country Planning Association was 'nothing gained by overcrowding'^[4]. But 'crowding' was what defined old cities that had created centuries of urban fabric based around walking and, for the past 100 years, transit fabric with tram-based corridors and railway suburbs that clustered closely around stations. The automobile was now needed if we were going to build space into cities. Thus cars began to be assumed as the basis of access in the new Functional City.

Infrastructure planning thus had to provide the space for the roads that linked the large residential blocks, large industrial sites, large commercial areas and large open spaces for urban hygiene. The great expansion of our cities outwards began and the need to try and clean up the older parts of the city also began as they were not nearly spacious enough and had messy mixed uses, causing many problems. Most of all they were not built around the car so they needed space for roads and parking to enable them to meet their new functional objectives. Car dependence was thus a product of the infrastructure planning for the Functional City. And the old urban fabric of the walking and transit city became something of a play-thing for traffic engineers and transport planners. It was simply a space to be able to join up traffic flows without respect for its historic functions and cultures (Figure 1).

Modernism in general seeks to find 'the one best

way' and deliver a manual of how to do this. Thus town planning and infrastructure planning rapidly developed a set of Manuals for delivering the Functional City. These Manuals of Modernism included the following:

- The best way to predict automobile traffic based on the Four Step Model through population and wealth predictions with simple rules for building high capacity roads connecting A to B in as simple a line as possible.
- The best way to separate out land uses and provide for the car based on various semi-scientific Statutory Planning rule books.
- Formulae for creating the best provision of open space as a percentage of any new development.
- Similar engineering models that could predict water, sewerage and solid waste requirements based on population predictions.

The Functional City and its Manuals of Modernism spread across the world like wildfire. Universities began teaching traffic engineering and town planning with all of its pseudoscience. Town Planning legislation enabled the processes to be made legal and the professionals who produced the numbers were treated like the doctors of city growth.



Figure 1. The overpass in Kolkata that collapsed in April 2016. The fact that such a road solution (through the old walking city fabric) could be considered in 2016 shows that the Modernist approach to infrastructure is still alive and well.

My experience of my home town of Perth was to see the suburbs of the 1960's and onwards as though that was the normal way to build a city. The city had a new Metropolitan Regional Plan in 1955 done by one of the world's great modernist planners, Gordon Stephenson. It used all the science of town planning and took the two old walking cities of central Perth and central Fremantle as well as the transit city from the 1890's tram and train suburbs, and grafted on a new automobile city on top of the old urban fabrics. Freeways were drawn up across the city and new suburbs were laid out for the next 50 years of wealthy city growth.

In the 1970's as the first oil crisis struck and the first questions raised by people like Jane Jacobs (1961) in *The Death and Life of Great American Cities*^[5], questions arose about the level of scientific basis and truth of these predictive Manuals of Modernism. Personal interests directed me to begin collecting data on cities across the world to observe how well they did with these new freeways and low density sprawling suburbs; data collection has continued to this day^[6-8].

The Manuals of Modernism were not just enabling car-dependent land use and infrastructure; they were also creating better areas of open space and better regulated building construction. Perth's regional open space acquisition proceeded rapidly over the past 50 years. The best aspect of this has been the acquisition of all river and beach frontage land which has been a great success story in Perth's Modernist phase of planning. However not all regional open space has been the most ecologically sensitive land, more like the 'land-left-over open space'. That was not seen as an issue in the Functional City model as you just needed ample spaces to ensure the health of people. There was no idea then that spacious car-dependent urban sprawl would be seen today as a major public health problem due to obesity, diabetes and depression, all related to the lack of human walking activity.

3. Phase 2: Postmodernist — 1980's to 2000's

Postmodernism was literally a time of uncertainty about the kind of Modernist Planning that had been unleashed. It was not certain what lay ahead but this movement did not much like what had been let loose on the world's cities.

Many European cities in this period set aside the predictions of the Four Step Model and decided instead to build up their original urban fabric rather than tear down what they had through freeways and road

reserves and car parks. In the U.S. the differences between the cities was marked with New York following the Jane Jacobs' philosophy and preventing the great freeway plans of Edwin Moses from bisecting their city, while Los Angeles and Detroit did the opposite and followed the detailed plans laid out by the Manuals of Modernism.

In Canada they did not have the money thrown at their cities like in the U.S. and hence Toronto and Vancouver retained much of their European urbanism while watching with some disdain as their southern neighbors rolled out the bitumen. In Australia, the cities were also very mixed. Adelaide refused to fill in their famous green space around the central city with a freeway as predicted by their Wilbur Smith report. In Perth we were also becoming a bit nervous about our famous modernist Metropolitan Regional Plan. This was the time that the Metropolitan Plan and its departmental processes had taken all the rail reserves out of the original Plan and had begun to set aside massive road reserves for the future. I had a conversation with the head of transport planning in the Department of Planning at that time who told me he had personally removed all the rail reserves and had implemented road widenings on every highway to 6 lanes; there were massive freeways and the interchanges he designed were created using a 50c piece or a 20c piece. All of these were based on the predictions of the Four Step model that showed large road capacity increases would be needed. In particular he said, "Perth will never need a rail system".

In 1979 the State Government closed the Fremantle Railway as it was not going to be needed in the future. Perth was going to be a car city and it would only need a few buses for those who could not drive or could not afford a car. Moreover it needed a freeway down through the western suburbs as predicted by the model and the best place to put it was along the railway line.

Something seemed very wrong to me. However, I was not trained to observe the beauty in the Plan or to foresee the science in the road capacity predictions. It seemed improper as an academic in environmental science studying oil vulnerability in cities, and it seemed wrong as a Fremantle City Councilor trying to look after the old walking city fabric of Fremantle and the old rail corridor that had created the western suburbs — all threatened by asphalt. In particular it seemed wrong when the price of oil quadrupled in the second global oil crisis and the world entered a global

geopolitical future where oil and car dependence suddenly was not so certain.

My uncertainty was shared. The public reacted to the plan as it had been progressed with huge concern that we were taking a wrong path. The State Government was thrown out in 1983 and a new era began that tried to patch together a new plan. A new study was done that showed it was not economics that had closed the rail line so a plan to electrify the system was put in place and not long after a plan was done to take the rail line deep into the car-based suburbs to the north. These suburbs were the products of Stephenson's Plan and the Manuals of Modernism. But they were failing. Employment was not going into the dispersed suburbs so everyone funneled into the Mitchell Freeway each morning and home again in the late afternoon and very quickly it had filled.

The politics of the car-based suburbs drove the State Government to build a 'railway to nowhere'. How could a railway to the northern suburbs ever work when all the models showed that people with wealth would only use a car? But it did work. People moved onto the railway in much larger numbers than any expert or model had predicted. Then by the early 2000's it was the turn of the southern suburbs to request their share of urban rail. It was good politics so it was committed to but it didn't fit the models, the theories or the manuals.

As part of the Postmodernist era the question was raised whether we were overdoing it with our roads. My colleague Jeff Kenworthy was asked to conduct the Road Reserves Review for the State Government; he observed that road reserve spaces set aside across the metropolitan region were equal to around 90 square kilometers^[9]. A vigorous case was made to keep these spaces, just in case. But the party was largely over and very few new big roads were planned until a recent phase of Federal Government funded projects created a sudden return to modernism.

There was indeed a halt to several of the major road projects — a freeway beside the river and through the middle of Fremantle were rejected in the ballot box and removed from further consideration. Similar responses were happening across the world's developed cities^[7]. The loss of urban fabric and natural environment in these road projects seemed to have been forgotten in the rush to provide scientifically-based solutions to growing car populations. They were excised from urban plans despite the cries of the purists who believed in the inherent truth from the universal truth

of the Four Step Model.

We produced two books at that time as we found it hard to understand what was going on and needed to find numbers on how different cities were handling this phenomenon of car-based planning. Both were based on the concept of 'automobile dependence', a concept that we had created to try and comprehend the nature of this problem^[6,7]. The concept was based on quantitative data comparing 30 to 40 cities around the world in their transport and land use patterns and used examples of cities that were standing up to this Modernist force. The concept is now used by nearly every city in the world (including Perth) as they all try to address the multiple issues surrounding too much car use in cities. But this did not mean a halt at the momentum of the Modernist city program; current views showed that there was not a good handle on the type of city needed and certainly the Manuals of Modernism were not replaced, though the cities tended to go a bit more underground on their plans.

How could cities find a way through the conflict between Modernism and Postmodernism in their infrastructure planning?

4. Phase 3: Emerging Sustainability — 2000's to Today

The next phase of planning led to the greater definition of the type of city that urban residents wanted: a more sustainable city. The Postmodern era had left a vacuum and the Bruntland Commission filled this. A global conflict had developed between the forces of progress (often labeled the economists but mostly pushing the Modernist view of the world) and the forces trying to stop progress (often labeled the environmentalists but really those who were Postmodern), the UN Commission on Environment and Development (1987) resolved this conflict by saying that there is a need for development but it must be sustainable development^[10]. It was no longer possible to do what the forces of Modernism wanted nor could you just stop everything, thus there is a need to reinvent the future differently. A new planning paradigm began to emerge.

However, this sustainability concept was not clear in what exactly needs to be done and certainly there were no manuals to follow. Everyone proceeded to develop strategies and try to see how the environmental and social aspects of development that had been neglected by the Manuals of Modernism could now be re-invented or rehabilitated. The processes of planning

became convoluted as the Manuals of Modernism predicted what was needed and then the structures of local, state and national governments had to try and consider how social and environmental factors could be used to modify the plans.

What did this mean for cities? What did this mean for planning and infrastructure? Cities, states and nations began trying to find a new way of development and it was not easy. I wrote my first paper on planning for sustainable development at a Royal Australian Planning Institute Conference in 1993 and the book *Sustainability and Cities* in 1999, but translating this into mainstream planning had to wait until the 21st century when cities and higher levels of government began producing more substantial planning documents. In western Australia, I was asked to produce the State Sustainability Strategy^[11] and this gave me an opportunity to see how a different set of manuals could indeed still create wealth but did not neglect social and environmental well-being.

Clearly sustainability demanded a much greater recognition of:

- the local community and the urban fabric that had grown around it,
- the value of the natural environment, and
- the importance of reducing our reliance on fossil fuels and other resources like water.

Around the world cities began to grapple with these concepts and some found a new consensus emerging that the city could still grow, indeed it must, but it had to do much better at reducing car dependence and the urban sprawl that was intertwined with this. Cities in North America such as Portland and Vancouver, in Europe such as Freiburg and Copenhagen, and in Asia such as Singapore and Hong Kong, began to develop a new set of Sustainable Urbanization Manuals^[7,12-14].

Cities began to see the value in their old urban fabrics with the need to redevelop back in and create much better quality public transport, walking and cycling in their cities. The public responses to planning insisted that planners now had to do something about place-making in special places, and had to try and control urban sprawl. The ideas were there but could they be delivered?

For many cities the ideas of Sustainable Urbanization were highlighted by the need to integrate transport and land use rather than allowing modernist urban scatter. Many cities tried experiments in integrating transport and infrastructure but usually failed, such as the attempt in Perth where a new Department

of Planning and Infrastructure was created but did not last more than a few years. The experiment failed as the top-down policy of integration was always agreed to but the bottom-up did not. They knew what they should do but the Manuals of Modernism remained firmly in place on both sides. And so the juggernaut of car dependent sprawl continued.

Water is a different story, though it had its origins in the same modernism from the 1940's. Without going into details, the water profession has generally found an easier transition to Sustainable Urbanization. In Perth the water story was quite dramatic; in 2001 it did not rain at all. The State Government went into crisis mode and set up a cross-government approach to saving water and looking at better alternatives. The Water Manuals did not have much to offer as constraints on resources were not part of the Modernist view of the world. But all kinds of conservation measures (and then seawater desalination technology) were found to work and since then the Water Manuals have large sections on reducing, reusing and recycling.

Solid waste has had a similar Modernist work-over though perhaps not as spectacular as the water success story^[15]. However, every now and then a crisis due to land constraints for landfill undermines the progress based on previous assumptions. Energy for power also began to be seen as something that could involve much less waste and much more local and renewable sources^[7,8,13].

Infrastructure planning in most areas was not quite so certain anymore and was beginning to emerge within a sustainability paradigm. However the Modernist Manuals for transport and land use have largely remained in place throughout this period though the first signs of change have begun to be observed. Throughout the world's developed cities, three things began to happen simultaneously: car use peaked and declined, public transport, cycling and walking began growing dramatically; and cities began to come back in faster than they were going out^[8,16]. The causes of these changes were multiple and include the following:

- Economic factors relating to the value of dense centers for the new knowledge economy jobs that need people to meet face-to-face,
- Urban regeneration becoming a greater force than urban sprawl with associated exponential declines in car use as densities increased,
- The new smart phones and tablets that enabled people to keep in contact with friends and work

colleagues at any time and place and which work least best while driving, and

- The culture of urbanism found to be so desired by the young and wealthy.

The Manuals of Modernism do not understand such trends or their causes. Wealth has always been coupled with car ownership and use, larger houses and suburban bliss. The demand for a more urban and less suburban city is now being embraced by people in ways that Modernism could never have done.

But how mainstream is it becoming?

5. Phase 4: Disruptive Innovation — Present Day to Immediate Future

The notion of Disruptive Innovation was first espoused by Clayton Christensen at Harvard Business School in 1995^[17–19]. He suggested that innovation did not have to be seen as a top-down process of technologies that were invented to cleverly and rationally replace those of the previous era. He suggested that innovation came instead from demand by people who saw an innovation and found it met their needs better than the mainstream market could see and began to purchase the innovation, despite it being seen as more expensive by those in control. Soon the innovation flips the whole system into a new way of providing services and the economy is mainstreamed with a new way of doing things.

Examples are given by Christensen of the 3.5-inch disk which was preferred over the 5.5-inch disk for memory storage despite it being more expensive per unit of memory. However the 3.5-inch disk was cheap enough and more convenient and eventually gave rise to the notebook computer, a major system change. The mainstream provider of the 5.5-inch disks went under — this is called the Kodak Effect.

The application of Disruptive Innovation to cities is only just being attempted, such as those highlighted by Seba (2014)^[20], but I believe it may provide us with a much better insight into how our cities are likely to unfold and how the Manuals of Modernism will finally be rewritten. Let me apply this to energy and to transport/land use.

Energy is rapidly moving towards the use of renewables, especially solar photovoltaics (PVs) on roof tops. In Perth the city has now 550 MW of PV on household rooftops, which is the size of a large coal-fired power station. These PVs are mostly on the larger but poorer houses in the outer suburbs^[21]. For most utilities facing this transition the temptation is to

first deny it is happening as solar is known to be more expensive. But people keep buying it because they have lower bills so it seems cheaper, starting a niche market that rapidly grows. Already the signs of an emerging system flip are showing and yet we are still not preparing for it^[21].

Utility engineers and the politicians they advise are still using the Modernist Manual which explains how a centralized power system works in an attempt to try to make solar fit. And it will not work. They need to construct a new Manual that enables a more distributed and participatory energy system to emerge^[22]. This system will continue to have a grid but it will have many more localized systems run by communities, industries and local governments; it will be based on smart control systems and battery storage and will eventually be 100% free of fossil fuels. This will be well in place by 2030 and will be unstoppable unless the Manuals of Modernism are applied as a fundamentalist set of rules.

The same will happen in our cities as they phase out oil and large-scale car dependence including the asphalt-oriented Manuals. The disruptive innovations of urban rail, especially light rail, and their associations with local walking and cycling within a dense urban center in a series of linked centers is the city of the future being imagined in most cities^[8]. The light rail phenomenon continues unabated in US cities where in ten years patronage increased 190%, heavy rail 53% and buses decreased 3%, during the era of peak car use. Across all the world's cities the emergence of urban rail as a faster option than cars stuck in traffic has now been quantified: urban rail in the past decade is now on average more than 20% faster than traffic and in some cities 50% faster^[8].

In China there are 81 cities building or completed metro rail systems and in India there are over 50 cities building metros. Throughout the Middle East and Africa, as well as the emerging cities of Latin America, urban rail is the preferred option as they can outrun the terrible traffic congestion.

In Perth this is very clear with the new rail systems to the north and south which average over 90 km/h and have top speeds of 130 km/h, going straight past the freeway 'car parks' at peak time^[23]. Nothing in the Modernist Manuals and the Four Step Plan would have predicted this.

Urban rail is disruptive because it is generally more capital intensive than buses and most transport planners who use the Manuals think that buses should be

just as effective. But buses are not competitive with urban rail quality and rail capacity is significantly higher and when provided immediately attracts the kind of land use intensities that cities are trying to attract. This is the system change that urban rail induces; it brings people back in to more crowded and less spacious locations because that is where they want to be. This new system keeps young talent in the city and the urban economy thrives without the need for cars (and oil). Exponential declines in car use happen when centers are built around a corridor of rail. Urban rail is now growing dramatically across developed cities and emerging cities as a result.

In Beijing the first signs of a peak in car use can now be seen (Figure 2). Similar trends are likely across all of the world's emerging cities and further undermine the Manuals of Modernism that are still in use.

The future direction of cities that are following the trend away from car dependence is to be more polycentric based around quality electric rail. Perth has such a plan^[24]. The polycentric, smart city of the future, with its focused land use and integrated transit-oriented development, is nothing like the Modernist Functional City with its commitment to endless space and car dependence. It will be:

- high density and mixed in its rediscovered and rehabilitated walking city fabric (not just in the CBD),
- medium density in its transit city fabric along corridors dominated by fast urban rail and accessible to all in the surrounding areas, and
- low density in the adjacent car-based suburbs (but with electric vehicles run by solar homes) where intensive use of renewables and other community-based technologies will be creating small local economies.

Driving this change will be the mainstreaming process that replaces the Manuals of Modernism:

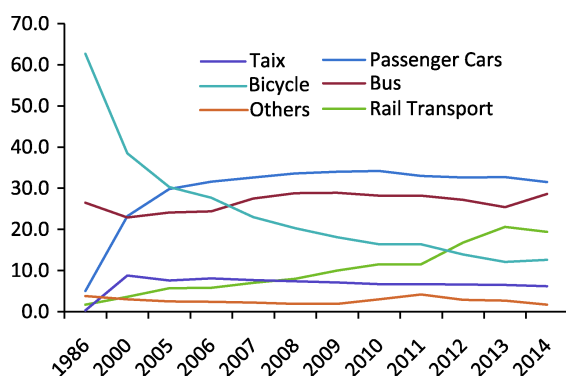


Figure 2. The peaking of car use in Beijing. This is likely to be the future in all similar emerging cities.

- The Four Step model will be replaced by a model that shows how the three urban fabrics of the walking city, the transit city and the automobile city will have their own regulations and performance criteria, with significantly less car use in the first two fabrics and modified requirements for space in the automobile city fabric.
- The Statutory Planning models will all be changed to reflect these three urban fabrics and their different requirements for density, mix and car dependence. As automobile city fabric begins to be redeveloped (already happening in the 1950's and 1960's suburbs), there will be a new set of regulations that can enable more walking city fabric in centers and more transit city fabric in corridors to enable the polycentric city.
- The open space plans will both respect the important natural features of an urban area and enable the kind of amenity that is necessary for each community and the density of their activity. In walking city areas the need for intimate urban parks and bigger footpaths will be more important than the need for some regulated percentage of open space.
- The water, energy and waste plans will have predictive power based on reducing, reusing and recycling as well as new smart, renewable technologies that fit into each area of the city differently.
- The consultants and models that are able to create Fit-For-Purpose solutions, as suggested above, will be responding to the Disruptive Innovations of the 21st century and enable our cities to adjust to these big changes.

6. Conclusion

The Manuals of Modernism have been the guide for infrastructure planning in most modern cities, since the 1940's. These Manuals have survived the era of Postmodernism and the era of Emerging Sustainability. They are unlikely to survive the era of Disruptive Innovation as the trends opposing their models are running heavily against them.

The new era will hopefully fulfill the desires set out for Sustainable Urbanization with a strong emphasis on outcomes. It will have a new set of manuals to guide the future of cities. The Manual for Transport could be called 'Fit-for-Purpose Transport Planning' and the Manual for Statutory Planning could be called 'Fit-for-Purpose Planning'. The first is hopefully

going to be much bigger than the second.

Conflict of Interest and Funding

No conflict of interest has been reported.

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