Forces Shaping the 21st Century:

Technology

Contents

Key Messages

- One of the biggest areas of uncertainty for the future lies in where technology will take our society. New technological innovations generally drive exponential change as they break open previously undiscovered or unsought applications.
- Technological advances have transformative and often unpredictable effects on the physical and social geography of cities. This can be clearly seen in the shape of the Auckland region, where development has continued to expand, enabled by technological advances in:
    - Transportation, moving from sail and rail to tram and automobile making us more mobile;
    - Water and wastewater infrastructure, improving public health and allowing higher densities;
    - Construction methods, transforming our built environment with CBD skyscrapers and low-cost suburban dwellings; and allowing higher densities
    - Information and communications technologies, changing the way we work, shop, play and relate to each other

  The largely 'fixed' form of modern cities, such as Auckland, has been built around these technologies and the expectation of their continued viability.
- Moreover, our cities have been built using technologies that rely almost entirely on fossil fuel as their energy source and thus are very susceptible to price and supply fluctuations in the petroleum market. Whilst technological advances in replacements for fossil fuels are likely, there is a danger that we will hold on too long to a false belief that technological innovation will provide all the answers - quickly. A future without fossil fuels potentially means iimmeasurable and deeply unpredictable changes for our city. We must be prepared to acknowledge and start planning for that immediately. At the same time, technological innovation will be a key component to a strategy of sustainability. Key technology goals for a sustainable city include:
    - maximising the substitution of information flows for energy flows
    - moving towards more localised solutions
    - using local materials and sustainable energy sources
    - utilising waste flows for free energy
    - adopting technologies which enable distributed systems; and
    - adopting economic development and social paradigms which are self organising and participatory, rather than hierarchical
- Known emerging technologies worldwide include: micro-electronics; telecommunications; biotechnology; and new materials/composites. A key challenge will be to apply these new technologies to a strategy of sustainability for our cities. Environmentally more benign technologies (e.g. wind power) are likely to be adopted as core technologies partially replacing those based on petroleum based fossil fuels become more expensive and less ubiquitous.
- A mega-trend transforming cities is the shift in emphasis from historic economies of scale (where costs fall because the scale of output is increased) to economies of scope (where costs fall because of synergies between complementary activities occur or because the overhead is spread across a number of activities). The implication of this is that cities no longer need to be big to be competitive. Increasingly the key to

success appears to lie in developing clusters and complexes of productive activity, and human organisation; creativity and advanced technical systems are also essential elements to this.

- Predicting the exact type of technologies that are likely to emerge over the next 100 years is almost impossible. Regardless of what the future looks like, building resilience into the city's infrastructure and urban form will ensure that the people of Auckland will be better placed to cope with both the unknown future and/or natural disasters**.** Examples of resilience might involve a less centralised infrastructural network and more localised/micro technologies.
- Governments in their role as regulators can influence the conditions that either encourage or discourage the development or adoption of new technologies.

Issues & Implications for Auckland

- Finding the right structures or processes to promote technological innovation in Auckland (such as the right economic *clusters*, *value chains* or *complexes*) while providing the appropriate physical and social infrastructure is very challenging. At present Auckland (and New Zealand) is at the leading edge of technology intensive industries such as boat building/marine, screen production and ceramics/new materials. However, we trail in other areas, such as uptake of broadband and investment in research and development. Harnessing the innovative capacity of the city and region as well as its particular elements or industries, will require a different approach to city management and planning in future, but will be essential to successful economic transformation.
- To date Auckland has invested heavily in infrastructure based on economies of scale (e.g. motorways, sewage/water/drainage systems, suburban housing). While the technology exists for much smaller and more localised or "less energy intensive" approaches, these have generally not been incorporated in any significant manner into the way in we currently build infrastructure. Furthermore, the long life cycles of much of our existing infrastructure (and its associated long term financing) means there will no doubt be a substantial time lag between the creation of new technologies and when they can actually be adopted in practice to replace existing types of infrastructure. Other technologies, such as information and communication technologies have transformed sectors, such as retailing, encouraging dispersal and conglomeration of centres outside traditional CBD or town centre locations.
- In Auckland, the changes wrought by the adoption of a variety of technological innovations and social changes have meant that the traditional centre (or CBD) is no longer the dominant centre for retailing, warehousing, transport, commerce, health, education or cultural activities. While the CBD remains the focus of financial and business services activity, the Auckland region has been emphasising development in nodes across the city that has the potential to greatly improve the resilience of the city's economy. Development is now polycentric.

Further Questions and Issues for Consideration

- If an ecologically more benign future is an important objective for Auckland, how do we incorporate technological innovation to achieve this, recognising too, the need to remain flexible in the face of unpredictable change?
- How do we focus on localised solutions for communities and business? What technologies are likely to become available to enable us to overcome problems and how can we best take advantage of them?

- How does city management enhance technological innovation? How can economic clusters, value chains and complexes be developed and encouraged through city planning?
- Concepts of multiple communities and multiple citizenship arise as ITC connects and divides individuals. How should Auckland maximise benefits and overcome divisions?
- What are the technology sets that will drive Auckland's economic performance in the next century and what are its key competitive advantages?
- New technologies change the way society develops. The cellphone for example connects us in new and different ways. How will society develop in relation to the technologies that emerge over the course of this century and what is the likelihood of greater social exclusion and division as a result of the digitilisation of society as technological haves and have nots emerge?

Preface

This paper examines some of the key issues for Auckland in how to best prepare itself for the future in a time of rapid technological change. It suggests that historically there has always been a causal link between technology, innovation, and city form, and that this is unlikely to change. It also attempts to pick up on general trends that have characterised periods of technological innovation while considering how these have affected cities physical and social geographies. Finally it raises a number of pertinent questions about Auckland's future. In particular it asks how Auckland can best compete against the numerous other cities and regions of the Asia/Pacific rim in attracting and retaining local and foreign talent, capital and investment into the city. Successfully achieving this end is usually considered essential to achieving the economic and social goals associated with being a successful city in a globalised world economy.

At the outset the writers would like to acknowledge their debt to the Cities^{PLUS} project in providing a template for this paper. The Vancouver focussed Cities^{PLUS} technological forces paper effectively synthesises many of the key issues relevant to all cities integrated into the global economy. This paper adopts a number of these broader trends and sub-headings but applies a local context. The paper has also drawn on P Troy (ed), *Technological Change and the City* as well as I Carter, D Craig and S Matthewman (eds), *Almighty Auckland.* Considerable attention has been given to the particularities of the Auckland situation especially with respect to its unique geographical situation and distance from many of the larger world markets and also implications of its historical dependence upon fossil fuel technologies to remain internationally competitive. 1.0 Introduction

1.0 Introduction

Since the Stone Age civilizations have been characterised by the type of technology they use and technology has always played a defining role in the creation and transformation of cities. As such, technological change has often been the springboard from which modern civilisations have leapt into periods of dramatic cultural, social and environmental change, usually spurred on by a population of people enjoying vast wealth creation and bringing about a corresponding reordering of social norms. Historically the most successful cities were those places that generated greater wealth by producing new technology and becoming centres of innovation, they weren't merely consumers of their neighbours' technological advances.

The greatest cities in the world are often characterised as hubs of culture and creativity. But they wouldn't exist for these "higher" purposes were it not for the critical role they play as a conduit for trade and economic development. Cities do this by providing a centralised location in which services and markets can operate and the trading of goods between people can take place. Access is another prerequisite and to prosper in post-industrial times cities need to provide comprehensive transport and communication networks.

Given the rate of technological progress in recent times, any attempt to predict the variety and types of new technologies we are likely to see even in the reasonably short term future is certain to come up short. At the same time there are critical issues relating to how we manage knowledge. A recent global study into future key business trends over the next 15 years found a majority of business leaders anticipating that investment on technological infrastructure spending will actually fall away while spending on knowledge management and customer service will increase substantially (Economist Intelligence Unit, 2006). It appears a period of

learning how to harness the full capacity of the technological gains made over the past 20 years is now needed as the infrastructure itself, now ubiquitous, ceases to be enough of a competitive advantage. In the 21st century cities will need more than ever to create an environment where the creative potential and transformative elements of city society can flourish, this will include both organisations and individuals.

Successful cities grow in dependence upon being located close to a desired resource or group of resources that give a place a significant competitive advantage over other locales. Technology, production, capital or culture provides a direct and powerful basis for urban identity and economy. For example, Detroit is Motor City (though it also became a casualty of being "motor city" and experienced a long-period in economic decline), or Motown; San Jose seems to have been swallowed up by a wider productive and technology driven urbanism, Silicon Valley; Mumbai and Los Angeles have taken their cue from cultural creativity; Guangzhou, Jakarta and Dhaka from manufacturing and industry; (Droege, 1995) and Auckland to be successful in the next 100 years needs to understand what its defining characteristics are while establishing a clear and realistic identity (Almighty Auckland, 276-278).

Is the city's bobbing and buoyant sense of itself based on its productive capacity and a confidence in its creative and cultural future, or rather, is Auckland's particular feel more about consuming and trading the nation's productive surplus rather than truly adding to it? What would make Auckland a defining and competitive city in the 21st century? Would it make more sense to focus on becoming a high quality "feeder city" for the neighbouring mega cities of Sydney and beyond into Asia. Or is it simply better to remain as the New Zealand end of a pipeline along which food, fibre and information flow outwards and new migrants, machines, consumables and information flow inwards?

2.0 Historical Patterns

The rise of the contemporary "planned city" began in the growing cities of Europe and the United States from the mid-19th century onwards. Initially urban planners sought to overcome the issues arising from problems with the unprecedented levels of pollution coming not just from industrial activities but also the rapidly expanding urban populations who were supporting the newly industrialised factories. Reticulated water supplies and underground water-borne sewerage systems helped reduce death rates from infectious diseases and improved hygiene within the urban environment. Gas and electricity distribution systems made public places lighter and safer, while the ability to light homes and factories provided the growing energy inputs for urban living and production. Suburban roads, trains and railways pushed out urban boundaries and enlarged the metropolitan living area so providing living space for more inhabitants. The invention of the telegraph and then the telephone provided the more powerful means of communication necessary to keep the expanding urban system working effectively (Cities^{PLUS}).

Technological changes have often wrought significant changes to the physical environment. One such example is the advent of reproductive technology that lead to increasingly smaller families and more women remaining in the work force. This innovation alone has had a dramatic impact on urban space. And yet despite such dramatic spatial restructurings due to technological shifts, to date most strategic planning remains focused predominantly on the "more predictable" physical land use planning. In the 21st century, at a time when society is facing the unpredictable forces of climate change, globalisation and scarcity of essential resources such as food, water and energy, such a limited approach is unacceptable.

Indeed the long-term framework is being developed in recognition of our greater understanding of the complex interrelated nature of the problems facing our society today. It is an attempt to begin the alignment of our understanding and knowledge of ecological functioning and time with economic functioning and time, the former working in much longer-time cycles than the latter.

History tells us that cities in civilisation have not always responded in a timely way to pressing social and environmental problems. The lessons were therefore learned the hard way. There is a growing body of increasing scientific evidence that hard lessons will again need to be learnt if our modern societies can't face the issues in a proactive way and try to understand where the most significant hits are likely to come from.

The port of Auckland early in last century (left: image courtesy of Auckland City Libraries [NZ]), and the same building in relief with the city behind, early this century. The Auckland of the 21st century is noticeably more vertical due to changes in technology and in particular the bringing together of steel, glass, HVAC systems, and electricity all of which enabled architects to create buildings that went up. Anyone who knows the early ferry building will still appreciate the part it plays in anchoring the city at the water's edge with its prominent design and human scale.

3.0 Key Issues for the 21st Century

3.1 Technological Innovation Patterns – Mega trends

Technological innovations are critical in determining how primary technologies evolve and are utilised within the city. An example of a basic innovation might be the computer chip. The secondary or incremental innovations that follow this initial innovation are everything that has followed including our ability to store huge amounts of information on such a tiny medium. This paper identifies some of the different impacts both actual and potential arising from technological innovation.

The Difference Between Basic Innovations And Improvement Innovations

Distinguishing between basic technological innovations and improvement innovations is important. The two processes have different consequences and patterns of occurrence. Whereas basic innovations create entirely new industries and products, improvement innovations make incremental changes to existing industries and products. Basic innovation waves have occurred regularly at 55-year intervals at least since the late 16th century. Incremental innovations happen on an ongoing basis (Cities^{PLUS}).

Basic Innovations Create And Transform Cities

Waves of basic innovations created new cities. For example, the basic innovations of the 1760 to 1780 period created the industrial cities of Northern England. Those of the 1840s to 1850s created the new frontier cities of Chicago, Toronto, Sydney and Auckland in the case of Auckland, arguably it was the application of steam power and iron to ships (permitting safer and quicker trans-oceanic voyages from Europe) and to a lesser extent improved firearms that allowed early colonial establishment. However it was the advent of refrigerated shipping and much later airline passenger services (for tourists and immigrants) that were the two key technological innovations to have a really significant impact on the city (Almighty Auckland, 26-28).

Innovation waves also transform existing cities. The same innovations that created cities, such as Auckland, transformed existing cities such as New York and London. Transoceanic steam ships suddenly enabled these cities to feed huge increases in population by expanding the hinterland upon which they could rely for food and resources to other countries.

Transcontinental railways connected cities on the coasts to the agriculturally productive rural interiors and electrical power made them centres of world industry. Electric trams and urban railways meant the activities of work and home could be separated. Cheap steel gave birth to high-rise buildings and information technology changed the shape of the workplace.

Low Cost Factors Drive Innovation Waves

History shows that in each wave of innovation, for a city to prosper, it had to have an associated driving low-cost factor or be a link in the economic system that produced them. Figure 1 illustrates the low cost factors associated with six innovation waves.

Figure One: Innovation waves and their Low Cost factors

1760-1780	Child labour
1840-1860	Coal
1880-1900	Steel
1930-1850	Petroleum
1980-2000	Information processing & communication
2030-2050	Energy and materials through bio- and nano technology

Much of New Zealand's competitive advantage in its agriculture-based industries lies in the combined application of innovation and lower-costs. Arguably, much of Auckland's advantage in the national context is its location and international connections (in terms of sea and air transport, telecommunications, and capital inflows) rather than the application of technology. (Almighty Auckland, 25-47). Auckland has tended to be a taker and adapter of new technology, rather than being the site of new major technological innovation.

Basic Innovations Change Technological Performance

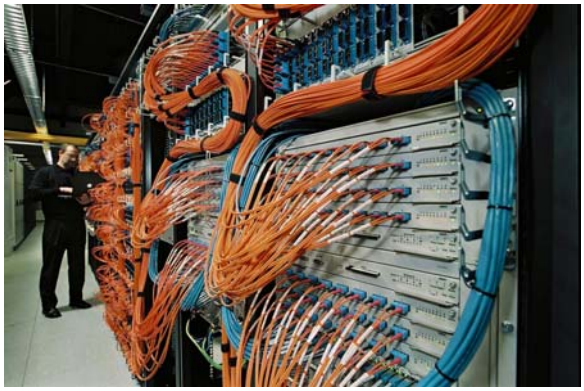
Each wave of basic innovation – from wood to iron, iron to steel, steel to composites, and composites to biomimics – brings quantum leaps in technical performance that radically change the way in which we can use technology.

Changes in water supply infrastructure demonstrate this pattern as cities have evolved from systems of open ditches to wooden pipes to clay, iron and concrete pipes. Water distribution distances have grown and quality has improved. A question for the next century is whether or not cities need to partially "devolve" back to a more localised solution for water management. This would include the adoption of decentralised small-scale technologies which operate at a local level and could greatly reduce dependence upon high-cost large-scale centralised urban water infrastructure. In a period where water scarcity is going to become a global concern, these technologies may offer cities significant benefits in terms of cost and waste reduction for water management and could potentially offer greater resilience and reduced risk in terms of security of supply (Cities^{PLUS}. 2004 and Lloyd, 1995).

Technology Changes Economic Systems And Social Patterns

The economic system of each technology set differs. Each of these "new economies" has a unique system of positive feedback loops that is inherent in the new technologies and in their energy requirements.

For the 1880-1900 wave of innovations, which was dominated by steam and steel, the feedback loops were the steamships, railways, steel and coal industries, agriculture, and agricultural equipment. The 1930-1950 wave dominated by the internal combustion engine and petroleum, connected oil exploration and production, refining and petrochemicals, the auto industry and aviation. The latest wave has of course been led by the rise and rise of information and communications technology (ICT), the feedback loops of which are still developing but appear to be computer communications (the Internet), ICT hardware manufacturing, software, information brokering, e-commerce, virtual services and institutions, and sensor networks.



A telephone exchange from 1898 (image courtesy of Auckland City Libraries [NZ]), and a server exchange of today

Cities And The Innovation 'Outsider Effect'

The people who introduce basic innovations are frequently from a different industry or discipline than the one in which the innovation occurred. For example, Sir Henry Bessemer, the man whose discoveries transformed the steel industry, was involved in glass and paints. The innovation of the theory of DNA that created the new discipline of microbiology and the biotech industry was due to a team consisting of two physicists, a chemist, and one biologist. New Zealand inventions are no exception to this rule examples being the Hamilton Jet Boat, the Gallagher Electric Fence, the Navman GPS Marine Product, all of which were created by people working outside of their area of “specialisation”.

The 'outsider effect' is also one reason cities are so innovative - new people are arriving all the time. Auckland has been receptive to migrants over its entire history, and this has brought a flow of new ideas into the city that have continued to generate and diversify the knowledge base.

At the same time, certain cities, industries or monopoly suppliers can become set in their ways and resist new industries or technologies, particularly those that challenge existing paradigms.

Dissemination Of Technology: An S-Shaped Curve

Historical patterns show that the technical performance and market penetration of new products and industries can be described with S-shaped curves. These curves are informative and useful for planning.

For example, if a technology is near the top of its curve, it likely does not have much of a future and will be supplanted by a new technology fairly soon. Steel, centralised power systems, internal combustion engine automobiles, and petrochemicals made with pressure and heat are all examples of this. Alternately, products in the middle exponential part of the curve have great potential for creating economic growth and for rearranging economies and

cities around them. Information and communication technologies are the prime example of this kind of product. Finally, technologies at the start of the S-curve, such as biotechnology and nanotechnology require extensive progress and will have many dropouts or failures.

History has proven a danger of getting overly engrossed in the glamour of new products that have great potential but are too early on the S-curve to deliver. There are risks of technological failure, institutional barriers, and inappropriate societal paradigms.

In terms of industrial innovation, New Zealand has generally adopted technologies as they have been developed overseas. However, some new technologies, particularly those associated with the agriculture or recreation/tourism industries have been frontrunners globally.

3.2 Critical Trends in Technological Development

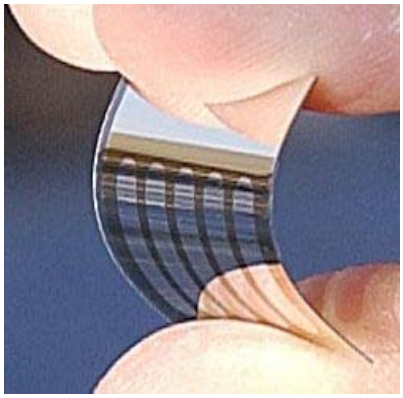
A number of technical analysts see four core technologies which have already become dominant or else are poised to become central elements in the productive systems of firms in the 21st century and hence are likely to be vital in organisational and locational strategies chosen. These are:

- Micro-electronics
- Revolutions in telecommunications
- Biotechnology
- New materials/composites (nanotechnology)

Of the core technologies, *micro-electronics* is the base of technological superiority of many sectors, notably automobiles and electronics but also financial services, and has had the most visible effects so far. Close behind, and a technology whose implications are now claiming the forefront of strategic attention, are the revolutions in telecommunications, notably through the convergence of computing and the telephone. The last two core technologies, and the ones whose transforming power is still less clear, are biotechnology and new materials/composites (especially advanced ceramics). This list is by no means exhaustive.

The other area where there are potentially huge technological transformations could occur lies within “environmental technologies” (e.g. wind power, fuel cells) which are also emerging as promising core technologies. The drive for more sustainable sources of energy is becoming increasingly critical especially as the price of oil escalates. Most of the world’s most economically advanced economies are entirely fossil fuel dependent and thus very susceptible to price and supply fluctuations in the petroleum market. The scale of transformation required for some of these industries to survive in a post-fossil fuel economy is likely to be unachievable with the result that whole industries are likely to disappear over the next century. In addition, a number of critical trends or “mega trends” can be observed from these technological changes taking place globally.

As mentioned earlier, knowledge management is going to be a critical concern for all users of technology over the coming century. Technology is also a key driver of globalisation. The related trend toward “mega cities” is partly why it is hard for Auckland to attract and retain skilled workers as our better paying neighbour across the Tasman and further abroad are able to offer more challenging and stimulating work at higher rates of pay (and whether true or not, the lure of lower tax rates).



New Energy technologies, a tiny solar cell (left) harnesses the energy of the sun while the turbines above (right) utilise the power of wind. Renewable energy is being seen as an increasingly important part in the energy supply mix of the future. However, it is not clear that "renewables" could ever reach the current levels of output provided by fossil fuel dependent energy technologies.

From Linear To Non-Linear Assumptions

Periodically, a 'bigger' phenomenon coincides with a wave of basic technological innovations. Examples include a cultural renewal (renaissance), a break-through to new ecological niches (commercial revolution), or the creation of a completely new system of thought (scientific revolution). When this happens, cities are doubly transformed.

Historians of science point to the paradigmatic change in science in the 20th century, from linear to non-linear assumptions as a new system of thought (or "Fordist" to "Post-Fordist" – or "flexible production" paradigm shifts in sociological/organisational management terms, see the "Worldviews" forces paper). This trend is reinforced by the non-linear nature of today's environmental and economic challenges.

From Economies Of Scale To Economies Of Scope

A mega-trend transforming cities is the shift in emphasis from historic economies of scale (where costs fall because the scale of output is increased) to economies of scope (where costs fall because of synergies between complementary activities or because overhead is spread across a number of activities).

The industrial paradigm that has dominated for the past 100 years is one of economies of scale. This is because dominant activities, such as moving bulk cargoes and heating and pressurizing enormous amounts of material require intense heat, pressure and energy. For example, making polyethylene requires heating ethane to 900 F and pressurizing it to 20 atmospheres. In this situation, it makes economic sense to pressurise larger quantities by capitalizing on efficiency gains of larger equipment. Similarly, doubling the dimensions of a ship triples the cargo capacity and decreases per unit transportation costs.

From the perspective of the city, we have invested heavily in infrastructure based on economies of scale. The water/sewerage/drainage technologies, for example, whose fundamentals remain unchanged today, capitalise on the efficiency gains of large infrastructure, such as storage dams, headworks, piped distribution systems, piped wastewater disposal networks and sewerage treatment plants.

And while the technology exists for much smaller and more localised or "greener" approaches (and have been used in rare instances), these have not brought about any significant change in the fundamentals of water/sewerage/drainage infrastructure, which are probably largely immutable. Furthermore, the long life cycles of much of this infrastructure (and its associated financing) causes substantial delays in technology implementation. So while it remains doubtful that they will have a substantial impact on overall urban form, innovative 'green-field' developments (such as Flatbush in Manukau) and sustainability projects (such as the Government's proposed development in Hobsonville, Waitakere) and will include some innovative methods for managing stormwater in particular at a more local level (Lloyd, 1995)

Despite these types of large investments in urban infrastructure in an information-bio-nano economy it will no longer be necessary to move and heat huge quantities of materials. Rather, the goal will be to infuse knowledge into smaller and smaller artifacts such as computer chips, sensors, and storage devices. In this economy information moves via electron flows as opposed to by the shipload.

This type of economy also requires the talents of small, self-directed teams of highly educated people that work within the context of a corporate mission statement and values as opposed to huge workforces that undertake repetitive tasks on assembly lines. There will be a shift from centralised hierarchical structures to more localised and decentralised patterns of economic production (Troy, 1995).

The "Post-Fordist" conception of work isn't solely confined to the sphere of production. Retailers have been reshaping their organizational and technological structures in an effort to improve efficiency and cope with the demands of a changing market. The effect upon the structure of the retail sector has been towards concentration at the upper (more expensive) end of the market and fragmentation at the lower (less expensive) end. Not only are product markets becoming more diverse, but retail strategies have also become more diverse. The relationship between retailing and manufacturing has become increasingly complex with the use of micro-electronic related technology, and the oligopolistic nature of the New Zealand retail industry has left most local manufacturers with little option but to fall in line with large retailer's demands (if they have survived at all). For example, large retailers have been placing more and more pressure on suppliers, including manufacturers, to absorb costs (such as Just-In-Time processes) (Greig,1995). This has impacted on social relations (e.g. 24 by 7 retailing), economic relations (e.g. more retail service employment and less manufacturing) and the spatial layout of the city (e.g. from the demands of large format retail) (Greig, 1995).

Arguably successful cities of the future will focus more on achieving economies of scope rather than economies of scale. They will spread overhead manufactured capital, such as roads, across a multitude of uses, and coordinate the overhead costs of educating a workforce and keeping it healthy.

Cities will also need to enhance their role in economic development to capture the free wheeling capital of the global economy through developing specialised clusters suited to their competitive advantage (e.g. film and marine in Auckland) easing the pathways of chains of production between interlinked companies in different locations (e.g. through technologies such as broadband) and creating complexes of productive activity (involving synergies between producers, users, public sector organizations and regulators) such as the recent proposal by the NZ Light Alloy Manufacturing Industry for the establishment of a National Rapid Product Development Centre (Auckland Economic Development Forum, May 2006).

From Physical To Virtual Connectivity

Moving information instead of people, energy, and materials implies a future that will be virtual to a significant degree. People will form social networks between virtual communities of interest as well as within them. The concept of a virtual community that does not exist in one

concentrated geographic location but is spread across the globe suddenly becomes possible. ICT enables people to do things for themselves that they previously had to rely upon others to do for them. It cuts out the 'middlemen' in the supply chain. For example, car dealers will no longer stock parts on site but will source parts as they are ordered from a centralised large warehouse. The result could be a huge loss of jobs within more local warehouses. A similar logic may apply to all retailing where the retailing function of cities shrink but the air cargo and delivery businesses grow.

An office couple in the 1940's (image courtesy of Auckland City Libraries [NZ]) contrasted against a contemporary call centre. Changes in technology have dramatically altered the work place spatially and the way in which we work. Call centres such as this above are often set up in countries on the other side of the world from where customers may be making calls. Technology has made the geography of distance less of an issue. Competitive advantage is now achieved through locating people-intensive businesses close to a labour supply that is relatively cheap and yet appropriately educated.

In a similar process, ordinary citizens and the volunteer organizations to which they belong have begun cutting out the middlemen of provincial and national governments as a means to influence international organizations and corporations. It is now easier for such organizations to effectively lobby corporates through the use of well-organised mail networks of members communities of interest and/or by distributing information about corporate practices via their own websites. ICT has seen the creation of wide variety of virtual communities as it has connected (and also divided) individuals in society in a number of ways, leading to the question of how should Auckland act to maximise the benefits of these virtual networks while overcoming the divides?

There are a number of divergent views as to how profoundly technology will alter social relations at a spatial level. Some of the earlier assumptions made about how technology would change these relations have to date proved unfounded. While it is true that for some mobility has definitely increased in the workplace, most workers still see having a centralised workplace as an essential social component to what they do and the interaction of ideas that occurs "face-to-face" as highly valued. Also for a great majority of people working in jobs in the manufacturing and service industries, being located at the workplace remains essential. In a similar vein many business leaders have identified "personalisation" as one of the five most important elements to business success in the coming two decades and see that "the human touch" will become more central to competitive advantage not less (Economist Intelligence Unit, 2006).

The implications of all this leads to some important questions, not the least of which is how Auckland can make itself truly attractive to the workforce of the future. Does the city in fact offer unique advantages to an increasingly mobile global community who are searching for dynamic, interesting and commercially responsive environments to do business where there are synergistic clusters of expertise, and sharing common interests?

Migration and Labour Movement

Economies of scope are about synergies between many individual talents and activities in close proximity. Current trends suggest "mega cities" continue to grow because economies of scope keep them regenerating in the face of changes and challenges. They become magnets to people from elsewhere especially from declining smaller cities and the countryside.

Is the role of Auckland within the complex of Australian east coast cities as a supplier of skilled migrants (as well as rugby league players) an important example of this trend?

Within cities in most developed nations, there is a limit to how far this can continue because rural populations are now very small, smaller cities can only decline so far and birth rates are below replacement level. To thrive into the future, cities must attract new talented migrants who can easily adapt and contribute to the productivity of the city.

Increasing Ecological Footprints

New technologies enable dominant cities to enlarge their footprints so that they can capture more free energy and use it for work. On a global scale, however, cities are exceeding the carrying capacity of the biosphere and causing renewable resources to become scarce. The new technologies of the 1980-2000 and 2030-2050 waves will be stimulated by these global scarcities, and many innovations will be an attempt to reverse this trend.

While Auckland has made the policy choice to move to a more compact urban form, how can we overcome the effect of past investments in suburban and peripheral areas (that resist anything other than incremental change) that have led to the creation of a fossil fuel and automobile dependent city.

How urgent are the changes we need to make to our ecological footprint? Where are the technologies that will assist us to make the change and how easily can they be incorporated into a city whose physical structure is largely already determined? How can Auckland exemplify, rather than be at odds with the '100% NZ Pure' brand and image?

3.3 Innovation Meta Trends

The performance parameters of new technologies are always changing, as are their associated impacts on cities. Technologies associated with the current innovation wave will:

- *Use significantly less energy and materials*. This results in smaller waste flows and smaller infrastructure requirements for cities.
- *Become self organizing and self-assembling*. This requires significantly fewer energy and material imports, and increased local use. Self-organizing technologies may also lead to more participatory governance systems.
- *Shrink in size.* This means that mechanicals and services occupy less space in buildings, and that utilities require less land.
- *Detect signals, process information and communicate much faster and more cheaply*. This will lead to cities that are more adaptable, flexible and faster to react. These cities will be plugged into themselves and their economic hinterlands so that they can be better managed and more responsive.

While it is virtually impossible to forecast specific innovations, some long-term Meta trends may be projected into the future and examined from the perspective of cities. The most significant of these mega-trends for technology include:

- *Discontinuity in design inspiration*: from ordering nature (creating things that never existed in nature) to mimicking and finding design inspiration in nature (such as spider silk).
- *Progressive lightening of materials*: masonry and wood to steel to polymers (e.g. Kevlar) to carbon nanotubes to biomimics (e.g. Artificial spider silk)
- *Progressive miniaturization*: vacuum tube to solid state transistor to nano-biotransistor; rebar to kevlar to nanotubes
- *Discontinuity in manufacturing technique*: from large 'heat and pressure' mechanical forces and assembly to nano-bio-self-assembly at ambient pressure and temperature.
- *Progressive improvement in the energy efficiency of machines:* history has shown at least a doubling of energy efficiency in changes from steam engine to internal combustion engine to fuel cells.
- *Falling carbon content and rising h2 content in fuels:* the progression has been wood, coal, oil, natural gas, hydrogen, with each successive innovatory wave.
- *A rising number of basic innovations:* 14, 21, 49, 41, in the past four waves and an estimated 100 in the present one.

4.0 Challenges for the Future: Technology and Auckland

When addressing the subject of challenges for the future of Auckland it's far easier to shed heat on the subject rather than light. For one thing advocates of a high-tech future for the city may frame the challenges in a very different way to those who advocate for a less technologically dependent society, or indeed than those who are on downside of the digital divide. There are some certainties; technology itself is not going to be the "cure-all" for a city facing increasingly serious environmental and social issues arising from the impacts of growth. And there are also a great number of forces at play that will demand more than just technological solutions. The relative advantages or disadvantages of geographies may have changed with technological advances but distance will always be an issue for Auckland and New Zealand. We only have to ask what would happen to a tourist industry totally dependent on fossil fuels if the cost of getting to New Zealand were to triple over the next 20 years?

Technological Change and Urban Services

One of the earliest and most enduring influences on Auckland has been the investment (or lack thereof) in transport services. Transport and land use are intimately connected. The way we organise and use urban space has shaped and been shaped by the transport investments we have made in the past. The ecological impacts of these decisions (both local and global) combined with the increasing costs of these choices (in terms of congestion, fuel prices and infrastructure) are forcing us to rethink our approach (Troy, 32-53).

Many people are now accepting that it is now a question of when and what will happen rather than if. Be it running out of fossil fuel, exponential increases in fuel costs or unacceptable environmental impacts - changes must occur. The very fabric of our civilization will change with the advent of declining fossil fuel usage. Virtually every aspect of a cities industrial, retail and business community will is currently dependent on fossil fuel. Immeasurable and deeply unpredictable changes are likely to occur unless a replacement energy source can be found.

Trams at the bottom of Queen Street dating back to 1925 (Image courtesy of Auckland City Libraries [NZ]) and the Britomart Transport Centre today. In the 1950's Auckland decided to pull up the tram tracks and pursued a city form predicated on the use of automobiles and roads. Now with petrol costs soaring and the environmental effects of private vehicle usage better understood the city is grappling with how to bring rail services back into the Auckland transport mix

Is there a danger that the Auckland city/region holds a false belief in 'natural survivability' and 'innovative capacity' to deal with a threatening situation? (Paul Bowker, pers. comm). Is the current strategy for increasing urban density going to solve Auckland's urban problems, including transportation, if the structure of our city has largely been determined by the use of automobiles and these may possibly be less ubiquitous in the future? If changing the level of mobility affects accessibility, how will this reshape the city? How do we focus on localised solutions to transport needs for communities and business? What technologies are likely to become available, if any, to enable us to overcome these problems and how flexible must we be to take advantage of them?

Urban development is also dependent on the availability of water/sewerage/drainage services, however Auckland has been largely unresponsive to technological change in the water/sewerage/drainage industry.

While a localised 'water friendly' environment can easily be imagined with current technologies (e.g. natural hydrological features, local drainage and water supply systems, urban artificial wetlands, etc) and has been adopted in 'trial' and city fringe projects, will path dependency, sunk costs and an abundant water supply (piped from the Waikato River) prevent widespread introduction of these technologies? Because the form of development has been affected by the existing technology employed in providing water, sewerage and drainage services, will any new approaches need to involve the right 'pricing' of these services so that we are led to seek technological innovation more quickly and broadly? How does our strategy for a more compact city (with presumably more hard surfaces) sit alongside options for local water friendly environments? (Lloyd, 1995).

Much has been said about the impact of the information highway and the significance of the technological developments in this field on the way we live, work, and seek our cultural stimulations. Cities have always been organised around the management of information but now we have a vastly enhanced capacity to exchange information. It's almost certain that our cities will continue to undergo major changes as a consequence. However, the causal connection between improved communications, economic growth and social change remains unclear (Lamberton, 1995). New Zealander's, especially Aucklanders, are "information hungry". We like to communicate. We can expect broadband, wifi, wimax, and 3g will increase in coverage, speed and bandwidth both virtually and exponentially within and across Auckland. Investment in infrastructure from the private business sector is also inevitable as

well as uptake (Paul Bowker, pers comm). How will the form of 'New Frontier' cities, such as Auckland, be shaped by the availability of communications services and by the flows of information? How will this express itself in the way we organise and use the urban space in which we live, work and play? What opportunities does this technology offer Auckland in terms of overcoming the tyranny of distance?

Postmodern theorists argue that consumption patterns are crucial factors in determining identity (both at community and individual levels) and that retailing and shopping malls have assumed greater importance as *cathedrals of consumption.* The changes that have occurred in retailing in Auckland over time have had a major restructuring effect on the city socially, economically and spatially. Among the most important developments to affect the structure of the retailing industry have been: the growth of self-service supermarket chains during the 1950s and 1960s competing with independent greengrocers, butchers, bakers, etc; the growth of discount stores competing with traditional department stores and using direct trading rather than wholesalers; and the dominance of regional and sub-regional shopping malls with key anchor tenants over traditional suburban ribbon or strip shopping and the central business district, resulting in the decentralization of retailing (Greig, 1995).

Innovations in information technology regarding how the retail industry operates have changed the relationship between suppliers and consumers. While the power relationships between retailers and manufacturers appear to have become more asymmetric over the past three decades (with the balance tilting in favour of retailers), the relationships themselves are vital for the future ability of Auckland to retain a healthy local manufacturing base. The sector approach to industrial development adopted by the Growth and Innovation Framework suggests that the future of local manufacturing and manufacturing location (e.g. in Auckland) needs to take into account not only comparative productivity and efficiency between local firms and overseas competitors, but also the relationship between local retailers and manufacturers (Greig, 1995).

Will a weak link between these industries result in a "tourist-led" form of retailing and urban restructuring with more limited local employment opportunities? Can a stronger local link be formed between retailing and local manufacturing to promote a more dynamic form of urban development, when the retailing oligopolies are based in Australia? How will future technological changes in retailing impact on Auckland's urban space, social and economic relations? What is Auckland's understanding of the role of retail in our economy and its spatial demands? What strategies are in place to address the role of retailing in Auckland's future - including its future in manufacturing?

Finally in the past the form of urban development was significantly affected by our understanding of how materials behaved and by the stage of development of construction materials. However, technological constraints on the size of buildings are now insignificant. Advances in our capacity to analyse and design buildings and in the three major construction materials (steel, concrete and glass) mean we can now build virtually any kind of building of any scale anywhere we want – the constraints are more likely to be social, economic, environmental and aesthetic. The role of design of our urban space has only recently become an issue of significance. If there are virtually no constraints on how we construct the built environment, how do we maximise social, economic, environmental and aesthetic outcomes in terms of design? (Marosszeky, 1995)

The City and Innovation

Innovation and technological change continually influence the manufacturing process and thus the structure of firms. These changes have had substantial impacts on the form and structure of the city because of the way in which firms have put the new technological possibilities into practice.

Although cities generate technological innovation, they are mainly focused on where the market is and where productive activity takes place. Due to New Zealand's predominantly rural economic focus (at least until recently) our cities have rarely been conceived or structured as effective communities or politically significant. It is possible to see the world as a set of competing city regions and there would be a number of benefits in paying more attention to the role of cities in innovation in New Zealand.

Encouraging more effective linkages within cities, between public and private institutions and individuals and firms will be important in maximizing the future economic potential of Auckland. With Auckland's economic fortunes now inextricably linked to the global economy, any major shifts in the activity of productive organisations globally and associated technological transformations which facilitate the way big companies are run, will have particular salience. Finding the right structures or processes for innovation in Auckland (such as economic *clusters*, *value chains* or *complexes*) and putting them together in effectively functioning systems which maximise the innovative capacity of either the city or a sub-unit of the city will require a different approach to city management and planning. While economic development plays a role in current city management in Auckland, it is arguably overtaken by the more pressing concerns related to providing transport and other city services (Droege, 1995). So how does city management enhance technological innovation? How can economic clusters, value chains and complexes be developed and encouraged through city planning?

The way we tackle environmental concerns may also be achieved best at the city level suggesting that we would need to strengthen our notion of community and exploit the natural advantages between Auckland and other cities. While we appreciate Auckland's high standing on the Mercer index, do we understand how to keep it there? The interrelationship between technology and ecology in the built environment has to date been predominantly about knowledge accumulation and problem identification, but it is now turning to providing solutions (e.g. wind turbines, fuel cells, localised water alternatives, 'green buildings', etc). If an ecologically more benign future is an important objective for Auckland's Mercer index rating, how do we incorporate these technological innovations, recognizing too, the need to remain flexible in the face of unpredictable change?

Social Change and Technological Innovation

As living standards have risen people have had a far greater choice in their domestic lives in a variety of ways. One of the main choices they have made has been to consume more urban space and to make themselves more comfortable.

This has traditionally been in the form of larger better equipped dwellings and control over private space – that is gardens. Another choice has been to spend more time on leisure and other non-work activities. A very high proportion of this increased private time has been spent in home based activities. As increased proportions of people take early retirement, and live longer (through improved medical technology), can we expect them to spend more time in and around their homes and to want private urban space in which to spend that time? Or will we see a trend toward apartment living and less private space in cities and consequently the demand for more public space? That is, will people want more public space for their passive and active recreation as well as their cultural and social activities, such as increasing demand for golf courses and a wide variety of sports grounds as well as demand for promenade space and centres such as the Viaduct Harbour?

Demographically family size is shrinking, people are marrying later if at all, and having fewer children while more women remain in the workforce. These social changes have occurred through family planning technology and tend to change the demand for transport services. For example, now that two members of many households work, minimisation of the journey to work in length or time will frequently produce a different result from the period when only one person worked – typically in a central city location (Droege, 1995).

Given the number and range of choices made available through new technologies about where and how people are choosing to work and live, where to locate their businesses, and where to shop and pass their leisure time, people have chosen dispersed locations and they use shopping, recreational and cultural facilities at different times. They seek convenience, comfort, privacy, security and economy in the ways they obtain access to those destinations. Moreover, they want to have that access as quickly as possible when and in whatever sequence they choose (Brindle, 1995).

In Auckland, there is more than one centre. The changes wrought by the adoption of a variety of technological innovations and social changes have meant that the traditional centre (or CBD) is no longer the dominant centre for retailing, warehousing, transport, commerce, health, education or cultural activities. While the CBD remains the focus of financial and business services activity, the off-centered location of many centres throughout the region reinforces a dispersed city environment.

The net effect of these forces, resulting from technological change and changing social behaviours is that we have seen and are continuing to experience major stress in the nature of relationships between transport and land use. How might technology be utilised to reduce this stress particularly in reshaping our social and economic activities?

Ecological Challenges

Technological innovation is a key component to a strategy of sustainability.

While technology waves have historically enabled cities to enlarge their footprints, the new technologies of the 1980-2000 and 2030-2050 waves will need to do the opposite (Cities^{PLUS}). One of the major obstacles in achieving any transformational change is what historians call *path dependency.* That is the decisions, practices, activities and investments that were made yesterday and how they affect today's choices, which in turn affect those open to us in the future. The very site chosen when Auckland was first established, the location of the centre and the subdivision pattern, including access space or roads, have had a profound influence on the way the city has developed. The inherited buildings, houses and formal spaces or the infrastructure, which constitutes the skeleton of the city, also influence its development and shape options open to it even when the activities carried out in the buildings differ from those for which they were originally built (e.g. international education) (Troy, 1995).

While some current technologies are not sufficiently advanced to allow society to progress to a sustainable level, others are, but are not being implemented. Key technology goals for a sustainable city include:

- Maximising the substitution of information flows for energy flows;
- Maximising the use of local materials and sustainable energy sources through the application of nano- and bio-technologies;
- Utilising waste flows for free energy;
- Adopting technologies which use energy far more efficiently (such as fuel cells);
- Adopting technologies which enable distributed systems, such as ICT; and
- Adopting new economic development paradigms and the new social paradigms (self-organising and participatory, rather than hierarchical).
- Moving towards more localised solutions

Today's wave of basic innovation is leading to technologies that make possible the reversal of cities' growing ecological footprints. For example, ICT facilitates substituting information flows

for energy flows, allowing the communication of information carrying electrons by wire instead of people in automobiles. Nano-technology and biotechnology will likely make it possible for products to self-assemble at ambient temperatures and pressures instead of using today's highly elevated temperatures and pressures methods.

However, with signs that the environmental crisis is either with us or just around the corner, major breakthroughs will have to be made to bring about transformational change. Auckland itself is already a significant consumer of ecological capital (MfE, 2003). If looking to the future one of the city's key competitive advantages is indeed its natural attributes and its ability to offer a high quality work/play balance, then it needs to demonstrate clearly the high value it places on its inherited taonga. It needs to ask what are the features of a clean/green built environment and how should these be incorporated further in Auckland?

Developing Distributed, Complex And Redundant Systems

Auckland has been subject to a variety of dynamic processes which have affected and been affected by social changes, technological innovation and changing choice among the private and public activities and endeavours of individuals and enterprises.

Harnessing economies of scope (synergies among large numbers of people) will be the main challenge for organizing the city of the future. Distributed, networked systems will become much more important for manufacturing, utilities and governance. In terms of governance, how does Auckland's current governance arrangements sit alongside the trend to distributed, networked systems?

With increasing economies of scope and ICT, cities of the future will likely carry out more functions in a distributed rather than centralised fashion. Replacing current economies of scale with economies of scope will likely lead, over time, to the replacement of centralised and large-scale systems and utility corridors will be smaller and perhaps even non-existent.

Increasing economies of scope and ICT also leads to more complex and redundant systems to create more secure and flexible cities. This implies that cities will not need to be big to be competitive and attractive, but human organisation and creativity and advanced technical systems will be critical to success. It will be possible for manufacturing and utilities to be very small-scale activities with minimal impacts on neighbouring activities. Mixed use will become more commonplace and attractive.

And quite possibly towering over all these questions are issues relating to Auckland's and indeed New Zealand's future integration with and into the Australian economy.

Recognition of the dynamic nature of land uses and their relationship with one another and the demand for infrastructure services should lead us to question reliance on physical determinist notions of static relationships. We should try to use the inherent dynamism in Auckland for planning for and providing these infrastructure services – for dealing with the unpredictable.

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Glossary

ICT – Information and Communications Technology

CBD – Central Business District

Appendix 1
Historical Patterns

This part of the Appendix draws on the Vancouver focussed Cities^{PLUS} technological forces paper, Chapter 1 of P Troy (ed), *Technological Change and the City* as well as Chapter 1 of I Carter, D Craig and S Matthewman (eds), *Almighty Auckland.*

International Patterns

Cities and civilisations emerged in history through the wealth arisen from the trade and exchange of particular goods and services, but the growth of cities was enabled principally by the development of agricultural technology and in particularly irrigation. The high productivity of agricultural food systems in comparison to the hunter-gatherer lifestyle allowed sufficient food to be gathered to support large urban populations. Hence the success of cities has always depended upon agriculture.

At the same time transport and access to a city has also been critical. Almost all major cities in the world, prior to the industrial revolution and the advent of the railways in the 18th and 19th centuries were located on coastal, river or canal locations. While ports, especially for the international transport of goods and passengers, have been critical for cities, the technology changes associated with shipping has reshaped ports and their facilities. More recently the development of air transportation has had a major influence on the structure of cities.

Before the existence of cities, early civilizations erected monuments, but when cities emerged, a new and more sophisticated technology of monumental architecture and building came into being. This architecture and the technologies that enabled it to flourish, continue to be perennial characteristics of cities and the outward expression of their identity and competitiveness with each other.

Manufacturing has been important for cities from the beginning. The city had the advantage of being able to feed full time specialists, and presented opportunities for cross fertilization of ideas and competition. Cities are the main source of new manufacturing technologies not only for themselves but also for their rural hinterlands. As such they are usually the centres of ideas and innovation.

Communications and military technologies have also been essential to maintaining control of city hinterlands. Their development was stimulated primarily by the need to defend or expand city hinterlands and to this day military innovation drives major advances in communicative and other technologies, the internet being just one such example.

The trade and military routes of cities have also been the routes by which ideas have travelled making cities crossroads for people and their ideas. Knowledge bases of civilizations are developed and stored in cities' people, informal networks, and social institutions, such as libraries and universities. This knowledge base makes urban centres locations of invention and innovation.

With the rapidly growing numbers of people living in cities over the past 150-200 years large scale and reliable supplies of water and city-wide reticulated sewerage systems became essential. Prior to these the health risks in cities were high and to reduce the risk of illness and lessen the decline in the level of amenity, land uses (such as residential and industrial) were separated.

Transportation technology began in the 18th century with turnpikes, macadamised road surfaces, sprung carriages and improved horse breeding, and continued in the early to mid 19th century with horse omnibuses and local railways. Developments in structural engineering, soil mechanics, pavement design and control systems have made roads safer and cheaper to construct and operate over time.

The railway was the first technological innovation to revolutionise land transport and the distribution of commodities - it allowed fast travel over long distances. Railways can be considered the lifeline of the early nineteenth century cities. Almost every city was located along a railway and in the United States, for example, the railway played a crucial role in the development of the west. Canals and railways vastly increased the sizes of the hinterlands that cities could control and draw upon, and consequently led to larger cities. Massive railway marshalling yards were also developed to handle the transfer of goods around the city. Then in the late 19th century the electric tram became the first serious alternative to horsepower within the city. It proved more energy efficient, flexible and cleaner than other alternatives (including steam railways) and turned the idea of an underground transport system into a reality. In the early industrial city of the mid-1800s movement was either by foot, horse or river and all activities required close physical proximity to reduce travel time to manageable levels. The electric tram assisted in the expansion of cities by dispersing settlement further away from the CBD*, impacting commerce and industry, as well as spatial layouts, leading also to the innovation of street shopping and the department store.

Each transportation revolution led to changes in the spatial layout of cities, their social geography, infrastructures and land use. The “New Frontier” cities of the mid to late 18th century (such as Auckland) were highly suburbanised and covered far more ground than traditional cities.

In the early 19th century, the vast majority of people lived close to work and mixed use was a fact of life. It was not until the days of mass electric transit that work and jobs could be spatially separated and residential suburbs, commercial centres and the industrial estate became possible.

But it was the widespread use of the automobile by the middle-classes that greatly accelerated the pattern of suburbanisation. The car provided mobility for the average urban dweller and allowed the rapid settlement of previously inaccessible areas (e.g. city areas between tram lines) on the periphery of the city centre. The car differed fundamentally from the electric tram, the subway and the mainline railway – in particular it was more flexible which meant that and car owners could tdetermine where and when they wanted to travel rather than being bound by routes and schedules.

A rapidly expanding car users market allowed households to travel further to major shopping centres, to carry their weekly needs home and using their refrigerators, store perishable food. This led to the demise of the corner store and the competitive reorganisation and relocation of retailing, especially to the suburbs as well as changes in the nature of the relationship between retailers and their suppliers (reflected for example in the development of *just-in-time* techniques). Changes in the way retailers related to their suppliers and to their customers thus led to changes in the demand for transport and information services.

What the car did for people, the truck did for goods. Before the automobile there was really no efficient alternative to the railway for moving goods. Trucks were free of fixed routes and schedules; they needed no elaborate terminal facilities on expensive inner city land and could make door-to-door pickups and deliveries.

Spatially, the automobile now dominates most cities with about one quarter of all land devoted to the movement or storage of vehicles so that “Instead of the automobile conforming itself to the limitations of the cities, the cities began to conform themselves to the necessities and services of the automobile” (G Roberts and P Steadman).

Changes in energy technology also had tremendous impacts on the location and development of cities. For example, as long as waterpower was the chief source of energy for manufacturing, cities located along rivers. The switch to coal and steam drew manufacturers to the coalfields. Electrical power freed industry from dependence upon coalfields are were subsequently able to relocate to cities where labour was cheap and widely available and/or where their markets were located. Electricity also extended daytime activities past sunset. It revolutionised urban transportation (the tram and especially the subway) which allowed for more dispersed social activities and enlarged the pool of labour available to work in industrial production.

Electricity enabled the invention of the elevator and telephone. The elevator coupled with the use of new materials and construction methods, reshaped the structure of urban components and altered the city skyline. Skyscrapers allowed for greater concentrations of activities and office workers in the CBD, while telephones interlinked businesses within the city and other major centres.

Before long the telephone began to have a dispersing effect however by allowing commerce and manufacturing activities to take place in cheaper locations closer to the urban fringe. Businesses no longer had to rely on close physical proximity between headquarters and manufacturing to coordinate production and distribution processes.

More recently major innovations in information and telecommunications technologies have presented an unprecedented range of options for individuals and firms to facilitate the exchange of information both locally and globally through mediums such as the internet. These innovations in commerce and manufacturing is continuing to alter the dynamics of urban land use in a number of ways. Technology gains means that Workers now take up less floor space than they did formerly, employees can be grouped closer together and do their own typing and record keeping, and possibly even more important is the reduced need for employees to be working together in the same country, let alone the same location.

Table One: Major Technological Innovations

1825	Steam Locomotive	George Stephenson
1853	Elevator	Elisha Otis
1876	Telephone	Alexander Graham Bell
1879	Electric Tramway	Ernst Werner von Siemen
1902	Skyscraper	George Fuller
1908	Automobile (Model T Ford)	Henry Ford
1930	Supermarket	Michael J Cullen
1959	First Commercial Jet Airline Service	American Airlines
1974	Consumer Personal Computers	Apple, Commodore

2.1 Historical Trends in New Zealand and Auckland

Before Auckland became New Zealand’s capital in 1840, tangata whenua understood the strategic value of the Auckland region’s biodiversity, warm climate, and its abundant land

and water resources. Maori were skilled agriculturalists, despite obtaining much of their subsistence directly from nature. Most travel and inter-iwi trade was undertaken on water, either coastal or within the Auckland region's major harbour and river systems. Portages allowed canoes to be hauled across the Auckland isthmus between the west and east coasts.

Although settlements had existed in one form or another in Auckland for over 1,000 years, it was the impact of British colonial settlement in the 19th century that set the pattern for the development of Auckland, the use of technology and related spatial systems. With fertile soils in a treeless landscape (due to volcanic eruptions), largely uninhabited after warfare among iwi, served by two harbours, Tamaki Makarau was a tempting location for a new city and capital.

The development of Auckland took place at the time when the Industrial Revolution was in full swing. As European industrialisation created increased demands for food and raw materials, the transfer of European technology and institutions turned colonies, such as New Zealand, into supply regions. Colonial ports cities, like Auckland, became trading and immigration focal points for their regions' link to European markets and imports. These cities also acted as bases for the opening up of new land, providing farmers, foresters and miners with goods and services which were essential to commercial production.

Unlike many other mid-nineteenth century settlements in New Zealand, rising overnight like mushrooms and disappearing almost as quickly, Auckland struggled through early difficult decades to a precarious prosperity. With two harbours facing both east and west, Auckland became the North Island's trading centre – first through ocean-going vessels, coastal traders and river boats; then through land-based railway trains to the south and (less convincingly) to the north; and later, in the twentieth century, through spreading of tarsealed roads and the establishment of the country's premier international airport at Mangere.

The early 1860's brought some prosperity to infant Auckland, the base for tactically inept but strategically inevitable British military victory over Waikato iwi. That war's end doomed the city to commercial depression. Recovery came not from national or international factors, but from the chance discovery of gold near Thames. In the longer term, Coromandel's quartz rock gold industry, always controlled from or through Auckland interests, laid solid foundations for the city's engineering industries and greatly strengthened local commercial firms and professional partnerships.

Very slowly Victorian industrial production broadened Auckland's economic base. Serving Australasian markets, local sawmills and sash and door factories developed, built on the kauri forests north of the city. .

Then from the 1880's, new transoceanic refrigerated shipping encouraged first the meat industry, then dairying into spectacular expansion. Once farmers could send with confidence perishable produce to the other side of the world, the scale of dairying and meat export activities rapidly increased. British capitalists established a string of meat works. Meat from these works, and from elsewhere on the local railway network, butter and cheese from a multitude of tiny dairy factories, and human passengers travelled the railway line to Auckland for loading produce aboard ships bound for the northern hemisphere ports. Auckland harbour's throughput dwarfed that of other harbours in the country.

The fist railway line in the region linked Auckland to Drury in 1864. Lines were pushed to Henderson and Helensville by 1880. The North Island Main Trunk railway, completed in 1908, strengthened Auckland, making it now the trading centre for a nation, not just a region. Metropolitan firms in Auckland could also take advantage of economies of scale and

agglomeration to invest in new overseas technology, such as the cream separator, roller flour mill and Babcock tester of butter fat content.

A modestly frequent steam-powered suburban passenger line developed, but was overtaken by an electric tram system after 1905. Tramlines snaked out from Auckland city to Meadowbank in the east, Avondale in the west and to Onehunga in the south. A steam railway linked Devonport with Takapuna and Milford from 1902. Auckland's tram system was ripped out in the 1950s and replaced with electrically powered trolley buses and diesel buses. From 1970, trolley buses also disappeared.

For several decades after the North Island Main Trunk line opened, New Zealand railways dominated long-distance passenger and freight traffic north and south of Auckland. But after the Second World War, this dominance slowly waned as the state highway system's steady upgrading saw car and short-haul trucking increase relentlessly. The increase was symbolised by the Harbour Bridge opening in 1959. The "coat-hanger" became a common shorthand symbol for Auckland until it was replaced by the Sky Tower in 1995. From the 1950s a new motorway system drove from Manukau in the south through the Auckland isthmus, dividing at Spaghetti Junction to a northern branch connecting via the Harbour Bridge to the North Shore and a north-western branch connecting to Waitakere.

The mid-twentieth century also brought other changes. From 1935, the first Labour Government's foray into import substitution industrialisation generated a host of new jobs in light and medium manufacturing industries. Typically, these industries like to locate close to markets and Auckland took a disproportionately large number of these jobs compared with other centres in New Zealand.

As incomes rose building costs remained stable and people opted for roomier rather than cheaper houses. Over time the average house and lot size increased, which meant that more suburban railways and tramways, sewers, water pipes and other infrastructure were needed. New suburban houses created a demand for consumer durables such as furniture and electrical appliances. The introduction of television in the late 1950s continued a trend towards suburbanisation of leisure, which had begun in the 1920's with the purchase of radios and the building of suburban picture theatres.

The development of utility services in Auckland began with the Auckland Borough Council constructing a short sewer in the Queen Street Valley. Ten years later, the city's Board of Works extended this to Wellesley Street and some of the inhabited slopes of the central area. Beyond limited reticulated areas, nightcarts patrolled Auckland's streets until the turn of the Twentieth Century, when a bubonic plague scare forced the creation of multi-municipality drainage works, including the sewage works at Orakei. A thirty-year long controversy over where to site the next works eventually saw the Mangere Treatment plant open in 1960.

Auckland's water was initially drawn from creeks and wells, but in 1873, Auckland city purchased the Western Springs estate and began to construct a reticulated water supply system. In 1902, councils began to construct the dams in the Waitakere ranges and following the Second World War, the dams in the Hunua ranges. Following the water supply crisis in 1994, a pipeline was constructed from the Waikato River.

A private Auckland gas company was founded in 1862 to supply private premises from its gas works on the corner of Nelson and Wyndham Streets. Town gas continued to be supplied from coke at its Beaumont Street plant until Kapuni natural gas began to flow to Auckland homes in the 1960s. In 1882, New Zealand's electric lighting first blazed forth from a Princes Street merchant's home. Queen Street was lit electrically from 1905 and Auckland City Council soon set up its own generator. In 1921 the Auckland Electric Power Board was formed along

with the Waitemata Board in 1924 and a few years after that electricity flowed from the Government's Arapuni power station on the Waikato River. Notable, in Auckland's energy history were the "blackouts" in the central city in 1998, caused by the failure of four underground cables.

People and goods aren't the only things to move within cities, the other essential item that flows across the city is information. The privately owned New Zealand Herald newspaper hit the streets in 1841. From 1923, the Government introduced public radio, until the 1960s when private radio was allowed to emerge and the Government shifted its attention to television. The electric telegraph took time to be developed, with a line from Auckland to Wellington only being achieved in the 1870s. In 1902, the Pacific submarine cable linked New Zealand to Britain via Canada for the first time.

While a couple of small local private telephone networks operated in Auckland in the late 1870s, real expansion did not occur until after 1900. An international Telephone connection was established in 1931. Microwave towers appeared from the 1960s, followed by fibre optic networks, satellite dishes and cell-phone towers.