portfolio construction forum

# Infrastructure - reliable earnings irrespective of crises

Magellan Asset Management | 19 August 2016

## 1. INTRODUCTION

The infrastructure asset class, when defined in a disciplined manner, generates reliable earnings from the provision of essential services to communities. Earnings are reliable because demand for infrastructure services is underpinned by long-term structural forces, and this demand is highly price-inelastic.

The key risks to earnings derived by infrastructure assets are changes to the structural forces that underpin demand or changes to pricing power. While pricing power could be affected by regulatory changes or by sovereign interference, history suggests the risk of this is low in OECD countries. Underlying demand for infrastructure services could arguably be impacted by terrorism, epidemics or technology disruption. History also suggests, however, that these risks have a limited impact on long-term earnings. For the foreseeable future, earnings of infrastructure assets will continue to be reliable.

Provided investors define infrastructure in a disciplined manner, the current short-term risks should not materially threaten infrastructure's reliable long-term earnings outlook.

## 2. INFRASTRUCTURE DELIVERS RELIABLE RETURNS

Infrastructure is a distinct asset class that delivers reliable earnings for investors over the long term. However, infrastructure should only be considered as a distinct asset class if it is defined in a disciplined manner.

This paper defines infrastructure assets as the investment universe of assets (a) that provide essential services to the community and thereby face reliable demand; and, (b) whose earnings are predictable because they are not affected by variables outside their control, such as commodity prices, competitive forces or sovereign risk. Infrastructure assets that meet these criteria typically generate reliable earnings and cash flows. Over time the stable, reliable earnings derived from infrastructure assets are expected to lead to a combination of income and capital growth for investors.

The universe of infrastructure assets is made up of two main sectors:

- **Regulated utilities**, including both regulated energy utilities and regulated water utilities. Utilities comprise an estimated 60% of the potential investment universe. They are typically regulated by a government-sponsored entity. Such regulation requires the utility to efficiently provide an essential service to the community and, in return, the utility is entitled to earn a fair rate of return on the capital it has invested.

- **Infrastructure**, which includes airports, ports, railroads, toll roads, communications infrastructure and energy infrastructure (such as oil and gas pipelines). Regulation of infrastructure companies is generally less intensive than for utilities and allows companies to accrue the benefits of volume growth. As economies develop and become more inter-dependent, it can be expected that the underlying levels of aviation, shipping and vehicle traffic increase, as will demand for all forms of communications and energy.

Both utilities and infrastructure companies provide an essential service while facing limited (if any) competition. Because the service is essential, the price charged for the service can be adjusted with limited impact on demand volumes. Consequently, earnings are more reliable than those for a typical industrial company and generally enjoy inherent inflation protection.

## 3. RELIABLE RETURNS DERIVED BY REGULATED UTILITIES AND INFRASTRUCTURE ASSETS REFLECT UNDERLYING STRUCTURAL FORCES

The remainder of this paper seeks to demonstrate that (a) the reliable earnings derived by regulated utilities and infrastructure assets reflect underlying structural forces; and, (b) provided these structural forces are not jeopardised, infrastructure assets will continue to derive reliable earnings over the long-term, notwithstanding the short-term impact of specific risks such as terrorism, epidemics or technology disruption.

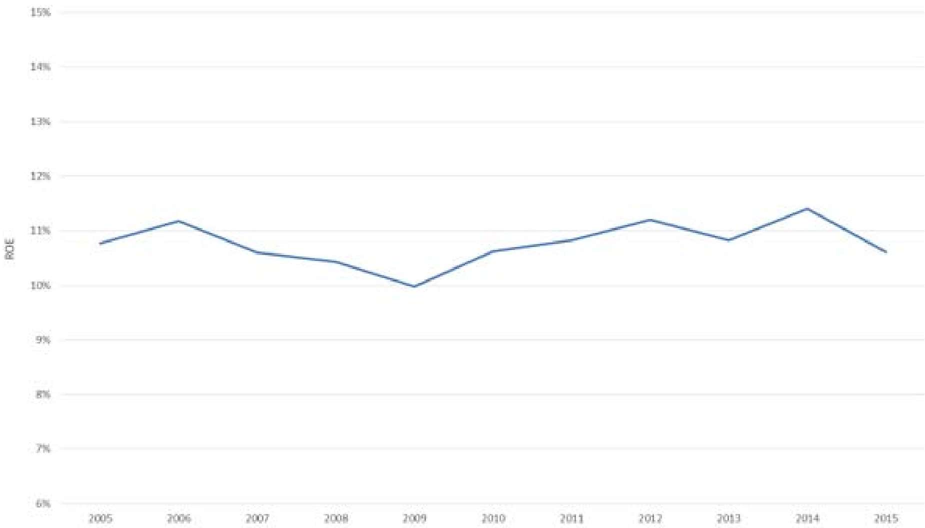
This paper is focused on three infrastructure segments – regulated utilities, airports and toll roads. These three segments have the largest number of constituents in the core infrastructure investment universe.

### 3.1 Regulated utilities

Regulated utilities, both water and energy, operate under a compact with their communities. Regulated utilities are natural monopolies, and are required to provide an efficient service and to invest for the long term. In return, the regulated utility is entitled to set its prices for the utility service it provides at a level that earns it a "fair" return on the capital it has invested in the business. The regulator – generally a government or semi-government authority – determines the fair return and, provided the regulated utility can demonstrate to the satisfaction of the regulator that it has operated in an efficient and appropriate manner, it is able to adjust the price of the regulated service over time to enable it to earn a "fair" return on the capital invested in the business.

The regulatory relationship is the structural force that underpins the ability of regulated utilities to generate reliable earnings over the long term. As a result of regulation, the utility is able to increase prices when underlying demand does not support the capital invested in the asset base, but will reduce prices when the return on capital exceeds a level determined to be appropriate by the regulator. Accordingly, the return on capital derived by the regulated utility over time should be reliable. This is illustrated in Figure 1, which shows the achieved normalised return on equity of a group of US-domiciled regulated utilities as at 31 December 2012, for the period from 2005 until 2015.

Figure 1: Return on equity of US-domiciled regulated utilities* (2005-2014)




Sources: Company accounts, Magellan Asset Management Ltd. The utilities include Alliant Energy, Atmos Energy, Consolidated Edison, ITC, Southwest Gas, Southern Company, Westar Energy, WGL, Wisconsin Energy & Excel

Figure 1 shows that while the period was one of significant economic volatility, including the Great Recession following the financial crisis, return on capital (as measured by normalised return on equity) derived by this group of US-domiciled regulated utilities generated extremely reliable financial returns.

Earnings regulation applied to regulated utilities limits the ability of utilities to maximise profits. Instead, regulated utilities are entitled to earn a fair return on the capital they have efficiently invested in the business. However, in return for limiting profitability to a fair return on capital, the volatility of the earnings derived by utilities is significantly muted.

Provided the regulatory relationship remains in place and the regulator continues to comply with the regulatory compact that regulated utilities have with their communities, then regulated utilities can be expected to continue to derive stable, reliable earnings across the economic cycle.

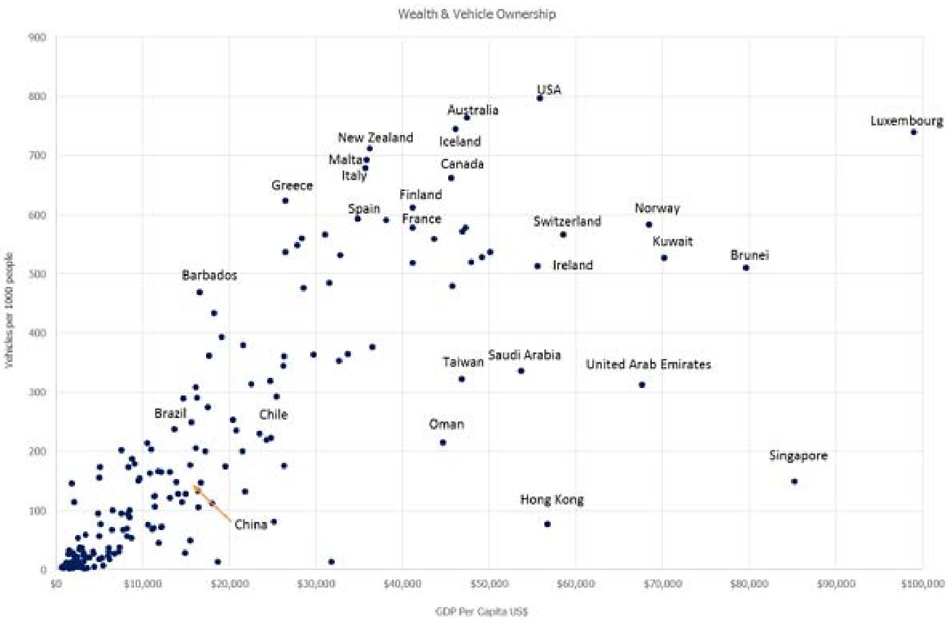
## 3.2 Infrastructure

Infrastructure assets such as toll roads and airports do not generally face earnings regulation. Rather, the price that toll roads and airports are able to charge customers for using the infrastructure service that toll roads and airports provide is regulated by limiting price increases to inflation (or something similar). As price is regulated rather than earnings, the earnings derived by toll roads and airports can be expected to be more volatile than earnings derived by regulated utilities. However, toll roads and airports can be expected to derive predictable earnings provided patronage volumes are predictable.

Experience shows that the demand for transport is a function of economic development. Increases to both population and average wealth lead to increased demand for transport. As a result, in a growing economy, increased demand for infrastructure can be expected over time.

For example, Figure 2 shows the number of cars per thousand people in different countries around the world. It demonstrates that as countries become wealthier, the demand for transport and mobility leads to increases in the penetration of car ownership. The direct relationship between the demand for transport and economic development is a structural force that underlies demand for transport infrastructure.

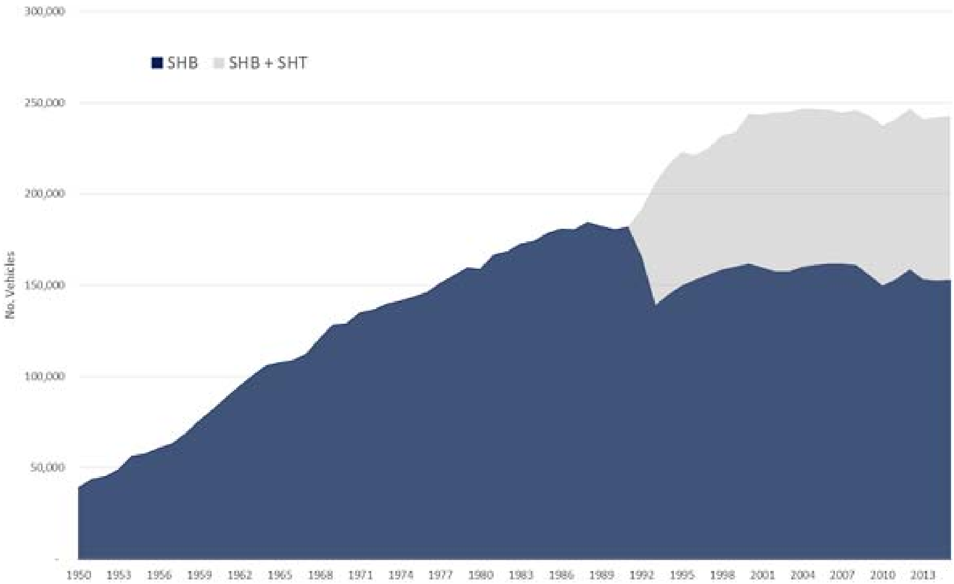
Figure 2: Motor vehicles per 1,000 people compared to GDP per capita




Sources: World Bank 2014, Magellan Asset Management Ltd

Similarly, Figure 3 illustrates the structural relationship between economic development and demand for infrastructure services. It shows the average daily traffic on the Sydney Harbour Bridge and the Sydney Harbour Tunnel from 1970 to 2015. Average daily traffic grew consistently until around 1985 and was then stable until 1993, when the Sydney Harbour Tunnel opened. The stability in traffic numbers was because the Sydney Harbour Bridge was effectively operating at capacity and so, while the local economy continued to develop with population growth and economic growth through the period, there was no available capacity for the underlying demand. When the Sydney Harbour Tunnel opened in 1992, average daily traffic promptly jumped to the historical trend and continued to grow from that point. Interestingly, average daily traffic appears to have stabilised again in the early 2000s, signalling a need for further capacity expansion (and in fact, a third crossing of Sydney Harbour is proposed under the NSW Government's West Connex project).

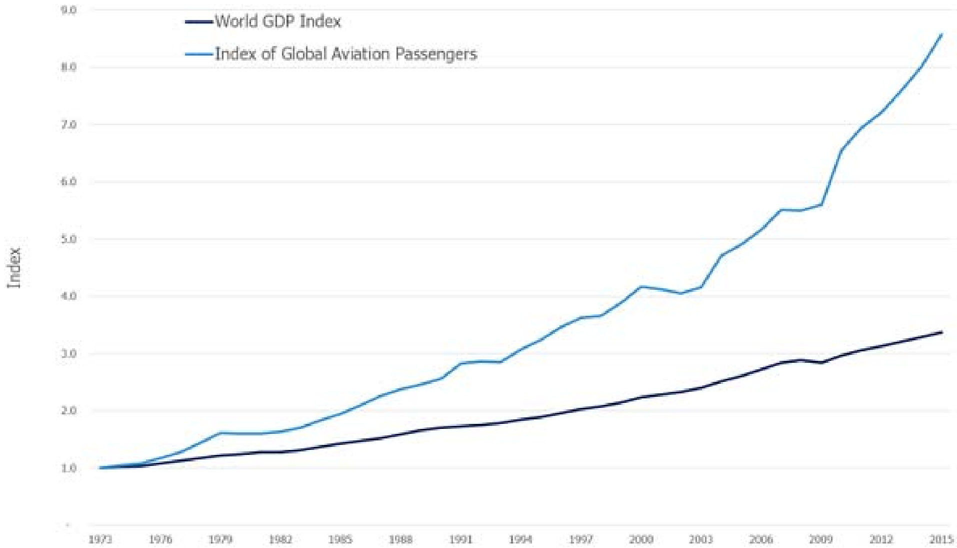
Figure 3: Sydney Harbour Bridge (SHB) and the Sydney Harbour Tunnel (SHT) average daily traffic
(1950 to 2015)




Sources: Roads and Traffic Authority, NSW Government, Magellan Asset Management Ltd

Global demand for aviation has also grown in a consistent manner over the long term. Figure 4 shows the growth in global aviation passenger numbers compared to global economic growth over the period. It is evident that there is a direct relationship between progressive economic growth and the increased wealth this has delivered, and continued growth in aviation passengers.

Figure 4: Global aviation passengers
(1973 to 2015)




Sources: International Civil Aviation Organisation, World Bank

While Figure 4 shows periods when the total number of global aviation passengers was static, over the long term, the increased wealth available to the populace as a result of continued economic growth underlies the continued increase in the total level of aviation passengers. This relationship between economic growth and aviation passengers underpins the usage of airport infrastructure over time.

## 4. SPECIFIC RISKS CHALLENGING INFRASTRUCTURE DEMAND

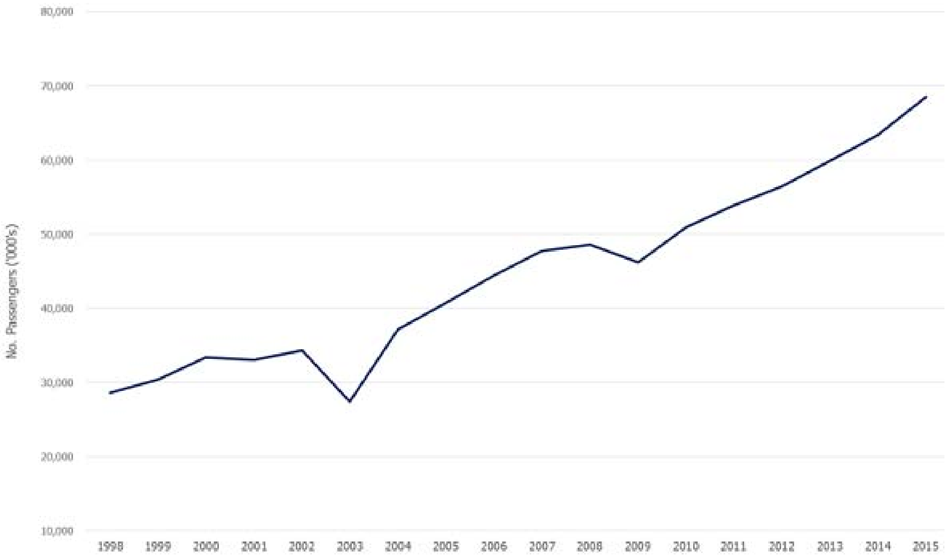
Demand for essential services is affected by a range of specific risks including terrorism, epidemics and technology disruption. There are a number of historical instances of terrorism and epidemics that show the impact on infrastructure demand. However, the impact of technology disruption depends on the nature of the disruption. The following discussion draws upon the historical experience of epidemics and terrorism to understand the exposure of long-term infrastructure demand - and hence long-term infrastructure earnings - to these risks. However, the discussion of the impact of technology disruption reflects the author's understanding of the most likely progression of technology that is widely expected to affect infrastructure.

### 4.1 Epidemics

Disease and illness epidemics can have a material impact on demand for infrastructure. However, history suggests that while these short-term shocks may affect demand for infrastructure services over the medium term, demand typically reverts to the long-term growth trend.

Figure 5 illustrates the temporary disruption to passengers at Hong Kong International Airport caused by the SARS epidemic prevalent in Asia in 2003. Note both the decline in aviation passenger volume as a result of SARS in 2003 and, importantly, the recovery of passenger numbers to the underlying growth trend over the 2004 and 2005 period. This demonstrates the resilience of aviation travel. This is a powerful example of the structural force underlying demand for airport infrastructure.

Figure 5: Hong Kong International Airport passenger throughput (1998 to 2015)



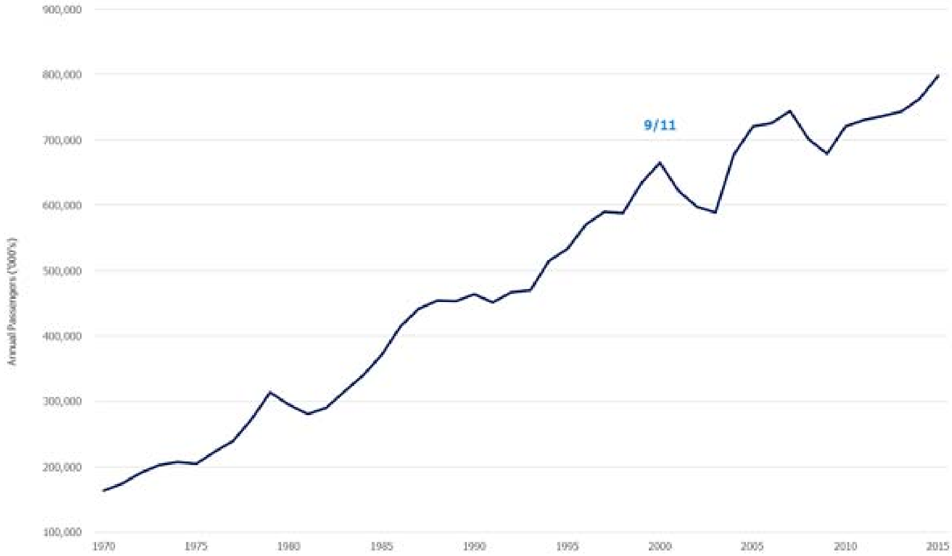

Sources: Hong Kong International Airport, Magellan Asset Management Ltd

### 4.2 Terrorism

Terrorism is another specific risk that unfortunately has become more prevalent over the past decade. Historical experience of the impact of terrorism on demand for aviation, and the resultant passenger throughput at airports, has been similar to that of epidemics. While there have been temporary disruptions to demand, passenger throughput has subsequently reverted to the underlying long-term passenger growth rate.

Figure 6 below illustrates the temporary impact on US passenger numbers following the 9/11 attacks and the speed of the recovery to a level of demand consistent with the underlying long-term growth trajectory.

Figure 6: US aviation passengers
(1970 to 2015)

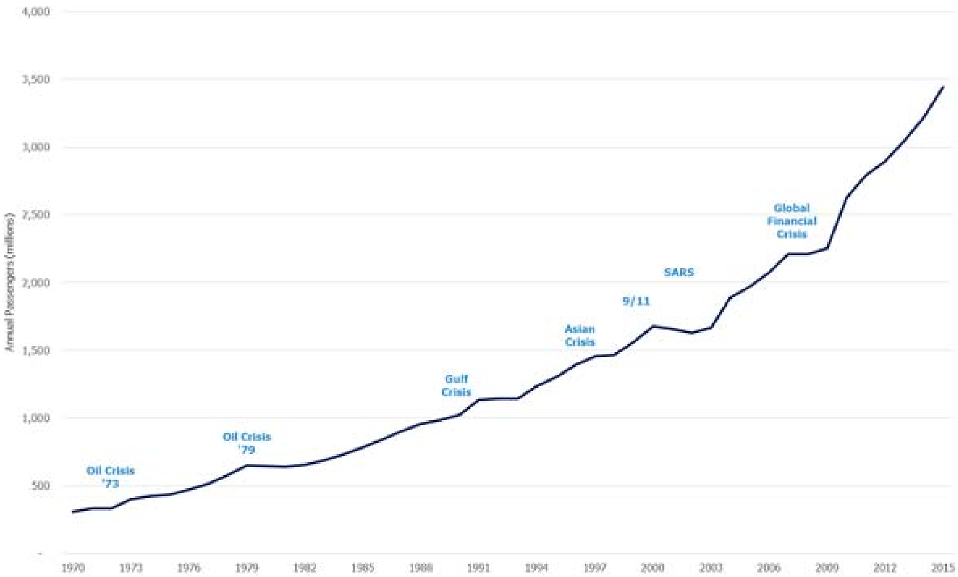



Sources: US Bureau of Transportation Statistics T-100 Market data, Magellan Asset Management Ltd

This demonstrates that while terrorism events may have a short-term impact on passenger throughput at an airport, the underlying structural forces that create demand for airport infrastructure have traditionally led to a return to the growth trend in the medium term.

More broadly, the Figure 7 illustrates the range of specific risks that aviation has withstood over time. Threats to aviation demand over the past 40 years have included oil crises, war, financial crises, epidemics and terrorism. Notwithstanding the negative short-term effect of these issues, global demand for aviation has continued to grow, reflecting the underlying structural forces.

Figure 7: Global aviation passengers
(1970 to 2015)




Sources: World Bank, Magellan Asset Management Ltd

## 4.3 Technological disruption

Undoubtedly, technological progress will lead to numerous changes in infrastructure investment. There are two key areas where this is apparent to us today. The first is the impact of the advent of driverless cars on toll roads, while the second relates to the continued progression of roof-top solar energy and battery technology and the impact on energy utilities.

### *4.3.1 Implications for toll roads of self-driving cars*

The concept of charging tariffs for use of land transportation links is an ancient concept, with historical records indicating user pays systems in existence in Arabia, the Roman Empire, Germany and in parts of Asia. The advent of motorised transport has advanced road design from catering for horses and foot traffic to structures that accommodate heavy vehicles that travel at much higher speeds. Construction, operation and maintenance of toll roads have progressively been transferred to the private sector which has enabled proliferation of an infrastructure subsector. But, with rapidly advancing technologies in vehicle automation and driverless cars, is the end of the road in sight for toll roads?

Modern toll roads, also referred to as Turnpikes, Tollways, Motorways, Thruways and Parkways, have developed into a legitimate asset sector for investors. Operating and financing models have evolved to provide investors with access to inflation-linked, regulated tariff income with the longevity characteristics of infrastructure.

There are essentially four variants of toll road forms:

- Urban radial roads;
- Urban orbital roads;
- Urban High Occupancy Toll (HOT) lanes; and,
- Inter-urban toll roads.

When valuing these roads, financial models must forecast traffic usage through to the end of the contracted concession period. In some cases, this can be more than 50 years. The advent of driverless cars therefore raises questions as to the impact of this rapidly developing technology on toll road traffic volumes.

Rapid advances in technology are set to deliver a transformation from driver-controlled to automated and semi-automated forms of vehicle operation. While the basic technology for driverless cars already exists, the shift to driverless cars will clearly take some time to occur and there are a myriad of social, regulatory and legal issues that need to be addressed before they become ubiquitous. But in the meantime, the technology will develop and will inevitably impact toll road usage.

The development of driverless cars could provide a boost to toll road traffic and earnings over the next 10 to 20 years. However, beyond that period, the impact on usage of toll roads is difficult to predict and may even be negative, as explained in the following discussion.

- **Autonomous vehicles**

  Cars are currently being produced that have Autonomous Vehicle (AV) capability. This means they have the capability to allow the driver to relinquish complete control over the vehicle in certain circumstances and are smart enough to know when conditions do not allow that to occur (e.g. when lane markings are confusing or non-existent).

  AVs are not driverless cars. Driving an AV allows the driver to hand over control of the vehicle but requires the driver to be ready to take back control of the car when needed. The vehicle will automatically keep a safe distance between itself and surrounding vehicles and, if needed, can change lanes. It will do all those functions more safely than a human - indeed, road safety authorities are supportive of the adoption of AV technology because of the expected safety benefits.

  So while the driver will still need to be behind the wheel and attentive to what is happening, the driving experience will generally be more relaxed, less stressful and safer than in non-AV vehicles.

While there are a raft of legal and regulatory issues that need to be solved before driverless cars become a reality, there are complex social/ethical issues that are even more important in the use of this technology. This is perhaps best illustrated when an AV is being used in a suburban street environment. In that situation, it is entirely possible that the vehicle would have to make a decision between running over a person that has moved into the path of the car or swerving into the path of a vehicle coming in the opposite direction, potentially putting the lives of the occupants of the AV at risk. Such "life and death" questions will take some sorting out.

In the context of such difficult issues, it is not surprising that the current thinking among road safety authorities is that AV usage is likely to be restricted only to motorways for some years to come, for two reasons. Generally, motorways have better and more consistent road markings and signage. And, very importantly, there is only very limited scope for an AV to be faced with situations that are difficult to predict in advance (e.g. a person running in front of the vehicle).

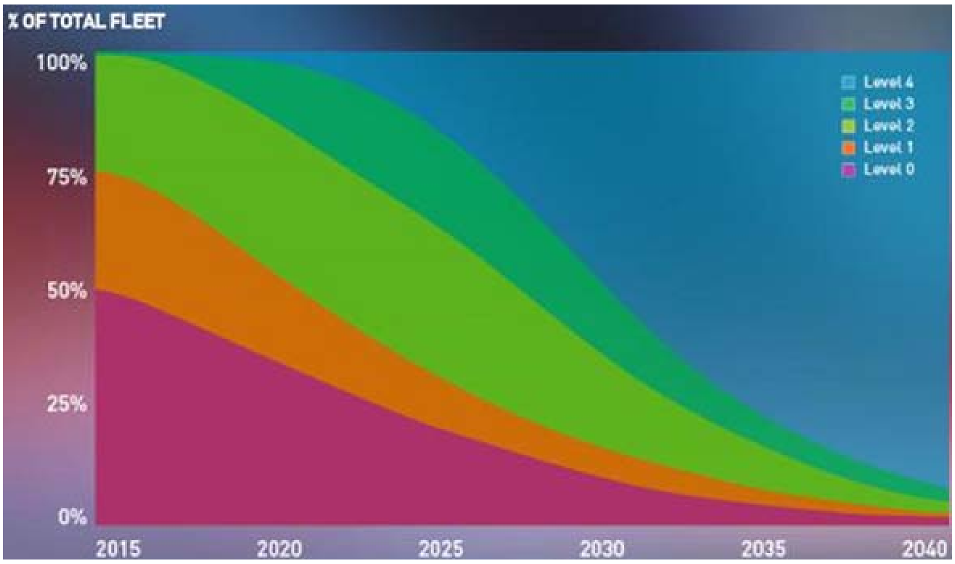
### The future

In the shorter term, tolled motorways are likely to benefit from AV technology because it will enhance the attractiveness to using the toll road over the free, non-motorway alternatives. Initially, that benefit will be marginal because relatively few cars will have AV capability. But over the next decade and beyond, as AV technology is rolled out in more and more cars, it is likely to be material.

Figure 8 shows a recent University of Minnesota study[1] which forecasts that within 15 years, almost 60% of the USA vehicle fleet would have either complete or limited self-driving capability, rising to 90% by 2040. Their forecasts shown in the graph use vehicle automation levels as defined by the National Highway Traffic Safety Administration of the USA being:

- Level 4: Complete self-driving automation
- Level 3: Limited self-driving automation (an AV)
- Level 2: Combined function automation
- Level 1: Function specific automation
- Level 0: no automation

Figure 8: USA vehicle fleet by automation level




Source: Levinson, D., "The End of Traffic and the Future of Transport Funding", University of Minnesota, August 2015.

AV technology is not a disruptive technology that could have a negative impact on traffic growth on the toll roads in the next decade. Quite the opposite – while its use is limited to motorway conditions, the toll roads are expected to be net beneficiaries. The increasing usage of AV technology on motorways will benefit toll roads in two other important ways.

Firstly, it will reduce traffic congestion on the toll roads because some congestion is caused by the poor behaviour of human drivers when changing lanes, breaking or accelerating. It will also reduce the number and severity of accidents – frequently a cause of severe congestion on the toll roads.

Secondly, it will increase the capacity of the toll road, particularly in peak periods. Toll roads currently can handle around 2,200 vehicles per lane per hour. A recent study by the University of California[2] concluded that full penetration of AV could see this capacity double. This is because vehicles will be able to travel much closer together at much higher speeds in much thinner lanes than is currently the case. A different study by Tientrakool et al[3] found that a 50% presence of AVs in the traffic mix can increase highway capacity by 80%. While these studies may prove to be optimistic, there is no doubt that the increase in capacity will be meaningful particularly for urban toll roads which are already capacity constrained during peak periods. This capacity benefit can be phased in over time by the creation of AV only lanes on the toll roads.

Longer term, this improvement in capacity will also be experienced by the free roads running parallel to the toll road thereby reducing congestion on the free alternative and removing the incentive for drivers to use the toll road. So, when AV technology is allowed to be used on non-motorways, there is likely to be a negative impact on toll road usage, at least until the free alternative roads become congested again.

- Driverless cars

The ultimate form of AV is a driverless car. Such a vehicle would be configured completely differently from today's vehicles. It would have no steering wheel or other controls and seats would be configured to best suit the needs of the occupants at the time. Driverless cars would allow the occupant to use the travel time productively or enjoy a greater range of entertainment experiences including video/TV/computers. They would allow greater interaction between occupants. And, they would provide enhanced mobility to those in our society currently incapable of driving a car (e.g. the old, infirm and young would be able to use the car without assistance).

Driverless cars will increase the capacity of both toll roads and their free alternatives as automotive networked intelligence results in optimising traffic flow, less accidents, and automatic rerouting. Ultimately roads may not even need traffic signals, lane markings or speed limits.

The fact that a driverless car trip will be an opportunity to be entertained will also reduce the utility of the time saved by using a toll road (i.e. drivers will be less inclined to spend $5 or $10 on the toll road to save say 15 minutes).

Alone, these developments are negative for toll roads given that usage of a toll road is almost entirely dependent on the actual or perceived time and reliability benefits of using the toll road.

However, driverless cars will also increase the demand for trips by reducing frictions to taking trips, introducing empty trips, and taking share from other modes.

A study by Princeton University[4] forecast that vehicle miles driven is likely to increase by between 5% and 20% when AVs reach 50% market penetration and when fleet penetration of driverless and AV cars reaches 95%, vehicle miles driven is expected to increase by 35%. The same study forecasts that this will be around 2040.

The era of driverless cars is also likely to be associated with much lower levels of car ownership. It will simply be more economic to participate in some form of sharing arrangement that allows much greater use of vehicles than to have a privately owned vehicle remaining idle. Again, this is likely to lead to an increase in vehicle miles driven as it will decrease average trip costs.

Another study by academics at the University of Southern Florida[5] showed that empty trips alone would increase total miles driven by at least 10%. These trips would arise because shared cars would drop off a passenger and drive empty to pick up the next occupant.

As an aside, it would appear that the clear losers of driverless cars would be the owners of parking stations and those making a living driving vehicles (at present, there are about 3.5m truck drivers in the US, forming the largest job category in 29 states).

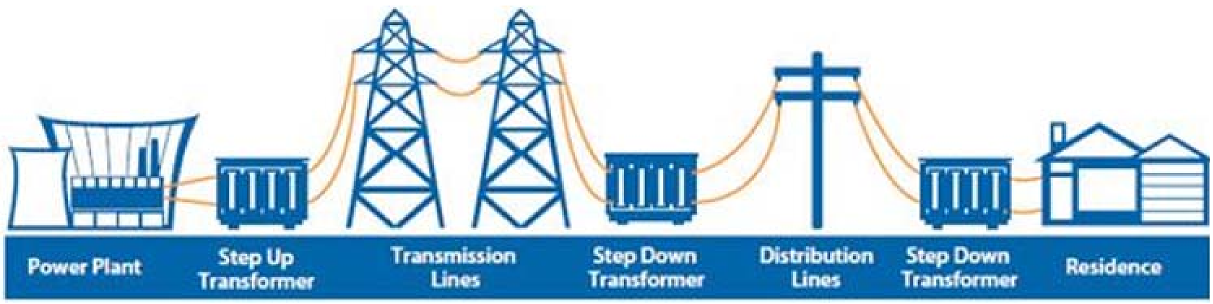
There is significant potential for disruptive technologies to materially impact a range of industries. None of the above quoted studies will be absolutely correct. However, AV and driverless cars will generally be positive for the earnings of toll roads, and particularly urban toll roads, over the next 10 to 20 years.

The long-term impact on toll roads will depend on the balance of the positive impact of the additional trips created by driverless cars and the negative impact of the additional capacity that is created on the free roads by the growth of driverless cars.

*4.3.2 The impact of improvements in solar energy and battery technology upon utility network infrastructure*

Electric utilities can be expected to provide stable earnings, regardless of macro-economic conditions. The stable earnings comes from both the reliable demand for energy and the application of strict price regulation to network fees.

However, the individual economics of an "electric utility" vary by company and need to be considered on a case-by-case basis. One option is to invest in transmission and distribution assets (i.e. the poles and wires, or more simply the grid). The grid benefits from being a natural monopoly and is therefore regulated to ensure it only earns a fair return on its investment. By contrast, companies operating in the power generation and retailing space typically fail to deliver sufficiently reliable returns. This is because they demonstrate an unreliable earnings profile, driven by the dramatic swings in the electricity price that occur throughout the year.




In recent years, the price of both roof-top solar and batteries have come down dramatically, begging the question as to whether these technologies will disrupt the reliable earnings profile of the grid. The discussion below considers whether the arrival of more-affordable roof-top solar and batteries undermines the investment case in the sector. The conclusion is that disruption associated with new technologies is unlikely to materially erode the financial returns accruing to electricity transmission and distribution assets.

The first electric grids were developed over 100 years ago. Since then, the level of complexity has increased as the scale of the operations have grown. However, compared to a century ago, the underlying principle of how electricity is supplied to consumers is largely unchanged. It is generated in a remote location and delivered to a household or business through a series of wires and transformers.

In the developed world, access to power provided by the grid is considered an essential service and underpins the modern economy while investment in electric grids has generally provided a steady, low-risk return. Despite new technologies, the investment fundamentals are not expected to change in the coming years.

- Batteries

  For context, the use of batteries in electricity grids is still in its early days. For large-scale batteries ("utility scale"), grid operators are largely at the trial phase while they try to work out how to harness the technology. Meanwhile, the home-installation of batteries is a similar story, with consumer uptake still in its infancy.

  However, in the long-term, batteries can be expected to play an important role in the grid. Why? Unlike all other commodities, using current technologies electricity needs to be produced simultaneous to consumption. This requires the construction of surplus capacity to deal with the periods of peak demand. This surplus capacity sits idle for the majority of the day (or even year) until there is a surge in demand. Batteries solve this by allowing electricity to be generated in off-peak periods,[6] such as the middle of the night, and stored until needed. In turn, this reduces the need for excess capacity – a win for both the utilities and its customers.

  Critically, the role of the grid in all this is largely unchanged because energy will still need to be delivered to the batteries.

- Solar power

  The impact of renewables on the grids is more complex. Some renewables are being installed at the residential level, typically roof-top solar, while others are being developed as larger utility scale projects. These are typically solar and wind-farms.

  Utility scale solar or wind changes nothing for the owner of the grid because the generation from the power station will still need to be transported to its customers. The dramatic decline in prices in wind and solar have made these technologies far more cost competitive with the more emissions intensive technologies. In recent years, global expenditure on utility scale renewables has outpaced expenditure on thermal power stations. As costs continue to decline, this trend should continue, with the electric grid providing a key link for this renewable energy to reach its customers.

Connecting large scale renewables to the grid is likely to be an important source of capital expenditure for the high-voltage "transmission" networks that transport the output back to population centres. However, the shift to renewables at the transmission level is not without challenges. Unlike existing thermal power stations, which have a reliable production output, renewables tend to be more unpredictable and intermittent in their power output due to changes in wind and clouds. Managing this variation in output requires operators of the grid to use reserve generators (often gas turbines) to balance the output from the renewables with the load or consumption of the customers on the grid. The difficulty for the operator of balancing this increases as the proportion of renewables increases. According to the US National Renewable Energy Laboratory, this additional cost on the grid of managing the variable output of renewable sources is generally not considered when considering its cost.

Where the renewables discussion gets more complex is roof-top solar. This is known as "distributed" generation because it is no longer centralised at a large scale generator. Theoretically, it does solve one of the problems of electricity supply - that is, that electricity needs to be transported a long-distance from the generator to the household. The long distances involved have been unfortunate as the further the electricity is transported, the more that gets lost as heat.

When roof-top solar is combined with a battery, it begs the question - why do customers even need to be connected to a grid? The short answer is that building a reliable, disconnected system is prohibitively costly. Being connected to the grid provides enormous redundancy with numerous generators and electric lines that ensure the power stays on for consumers - especially in weeks when the sun isn't shining. And finally, not everyone in the community has the ability to self-generate.

The current installed cost for a reasonably sized solar and Tesla battery package is approximately A$20,000. Except for households with extremely low electricity consumption, this system would only act as an offset and would not allow for a full grid disconnection because the system would not be able to supply enough power to meet the requirements of most households in all conditions. For example, the new 7kWh Tesla battery is rated to put out 2 kilowatts of continuous power (3.3 kilowatts at peak). A kettle and toaster can require over 2.5 kilowatts, which when combined with a hairdryer can easily pass 4.5 kilowatts of "load", exceeding the peak capacity of a single battery.

Austrlian think tank, The Grattan Institute, published a research paper in 2015 that addressed the cost of building a system capable of full grid disconnection. A typical Sydney household wanting to fully disconnect from the grid would require a system worth $34,200. However, this system would only be 95% reliable (i.e. the house would be without power in 1-in-20 days, on average). To be 99% reliable, the cost rose to $52,200. For 99.9% reliability - still below the level achieved by a grid - the price jumped to $72,200. The same analysis highlights that using this disconnected system would cost the household over 5.5 times more than if it had simply opted to draw power from the grid.

Other studies in different markets have estimated the cost of a disconnected system to be eight times higher than simply drawing power from the grid. Even expected declines in technology costs are unlikely to render it economic to disconnect from the grid, with an 80% reduction in the solar and battery costs still leading to a system that is 2.5 times the current cost of grid.

While the cost of installing the system may come down in the future, there are still significant barriers to mass adoption. Many homes will have insufficient space available for all the requisite equipment to be installed, whether it's garage space for batteries or roof-top square-metres to install the solar panels. Some disconnected systems can include a back-up generator, however, in a relatively densely-populated neighbourhood, neighbours may have complaints about the noise. Then there are apartment owners without space for panels, home-owners with roofs facing in the wrong direction, or those with shadows from trees and other buildings. Future growth in population density is only likely to exacerbate these issues. And, what about renters? They won't want to pay to have equipment installed, and owners may be reluctant to spend the money given it's typically the renter who makes the saving from the energy the system generates.

Even for those households with adequate roof-top space and large solar/battery-systems, there is still a benefit in staying connected to the grid. It allows excess electricity to be exported back to the grid, an example being when the owners are away on holidays or out for the evening. This leads to a future where the grid's role becomes a facilitator of trading between household "generators" rather than as a pure delivery mechanism.

For the reasons above, for the foreseeable future, disconnecting from the grid will remain a poor financial decision for many customers - and even then, there will remain a significant number of customers that can't disconnect at all. That's not to say there won't be continued growth in roof-top solar and batteries, but customers are likely to use the technologies as a compliment to the existing network. In turn, this will mean that regulators will need to review network pricing models. The grids themselves will need to work to adapt the network to deal with the changing flow patterns of electricity.

When things change, it is rare for all stakeholders to be winners. The worst impacted part of the energy supply chain will be the utility-scale scale thermal generators - gas, coal and nuclear power - as their economics are damaged by ongoing growth in renewable generation. While many of these fuels will have a place in the fuel mix in the coming decades, the transition to an increased renewables share in the market is likely to be problematic for them.

Fundamentally, the grid will continue to be an important piece of infrastructure in the community. So for now, utilities remain a reliable investment.

## 5. CONCLUSION

The infrastructure asset class, when defined in a disciplined manner, generates reliable earnings because demand for infrastructure services is underpinned by long-term structural forces, and this demand is highly price-inelastic.

The key risks to the earnings derived by infrastructure assets are either changes to the structural forces that underpin demand or changes to pricing. While pricing could be affected by regulatory changes or by sovereign interference, history suggests the risk of this is low in OECD countries. Underlying demand for infrastructure services could arguably be impacted by terrorism, epidemics or technology disruption. History suggests, however, that these risks have a limited impact on long-term earnings. For the foreseeable future, earnings of infrastructure assets should continue to be reliable. Provided investors define infrastructure in a disciplined manner, the current short-term risks do not materially threaten the long-term reliable earnings outlook.

## ENDNOTES

1. Levison, D, "The End of Traffic and the Future of Transport Funding", University of Minnesota, August 2015.

2. Shaldover et al, "Impacts of Co-operative Adaptive Cruise Control on Freeway Traffic Flow", 2012

3. Tientrakool, Patcharinee, Ho, Ya-Chi, and Maxemchuk, Nicolas M., "Highway Capacity Benefits from Using Vehicle-to-Vehicle Communication and Sensors for Collision Avoidance," Vehicular Technology Conference (VTC Fall) 2011 IEEE.

4. (footnote: Bierstedt et. Al. 2014, "Effects of Next-Generation Vehicles on Travel Demand and Highway Capacity", Princeton University)

5. "Highway Capacity Impacts of Autonomous Vehicles: An Assessment" 2013 Professor Pinjari et al)

6. We note that batteries also have the potential to reduce the amount of 'wasted' energy that disappears as heat due to the resistance of the wiring used in electrical equipment. This heat loss is worst in the peak period, therefore using batteries to "flatten" the demand profile of the grid has significant implications for grid efficiency.