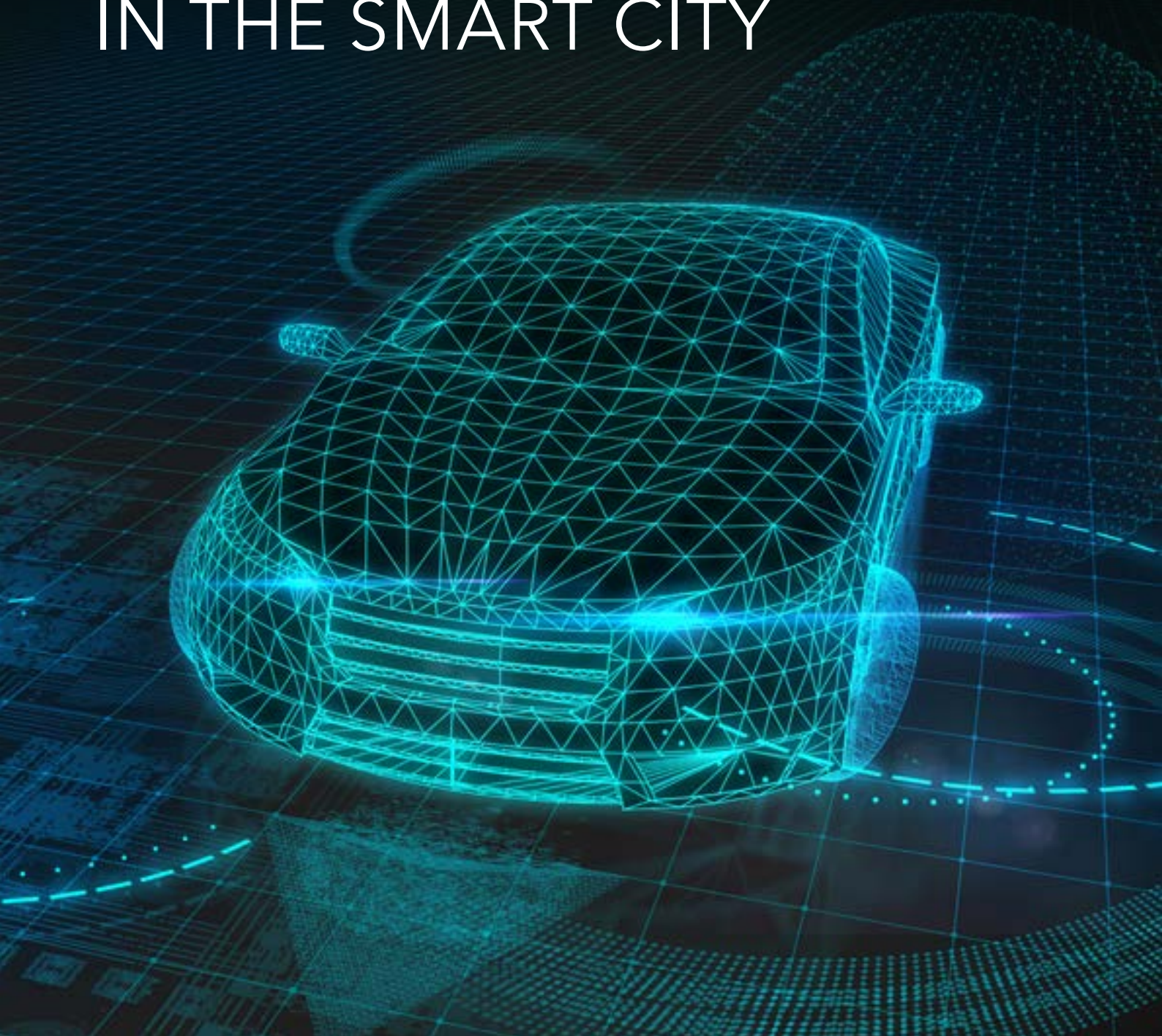


# TRANSPORTATION IN THE SMART CITY



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# Introduction



Patrick Sheehan

Our view of the future, as we grew up, was formed by TV and films featuring cars that drive or fly themselves. Future cities were to be places where vehicles flew freely and quickly through gleaming towers.

As far back as 1964, General Motors introduced its concept car, the Firebird IV, which anticipated handing the car's controls to an automatic, programmed guidance system and travelling in comfort and absolute safety at more than twice the speed possible on today's expressways. This sunny, well-ordered world didn't happen; but now it is being imagined anew.



Rob Genieser

Today's vision is of smart connected vehicles zipping around cities at high speed while their relaxed passengers breeze through social media or entertain themselves with the latest virtual reality. No more accidents, traffic jams, road rage. The old and infirm become independently mobile. Smart connected vehicles sense, record and relay information to deliver a transparent real-time view of the entire transport nervous system.

The valuations of companies such as Tesla and Uber, to say nothing of Apple and Samsung, surely point to a strong current of belief that this world is soon upon us. What are the implications? Here are three:



Fabrice Bienfait

- Saving lives. The number of people killed on roads around the world is around a million or so a year, which we accept as if it were 'unavoidable.' These losses per year approximate the number of people killed in the Vietnam war, on both sides including civilians, during its entire period. Road deaths could largely cease.
- The end of oil. The half of total global oil production currently poured into vehicles could largely be eliminated. Imagine the positive impact on urban environments (as well as the geopolitical impacts). We could all breathe in cities again.
- People-friendly cities. Our cities, long surrendered to the automobile, could be radically re-imagined. No need to find a parking space. No need to look both ways. Perhaps less need to buy a house near the centre, or conversely avoid a property on a busy, polluted street?

The advent of such a transport utopia has been long anticipated. But while there have been false dawns, this time, belief is shaping reality. A growing conviction among technologists and investors is already affecting the allocation of resources. In addition, transport utopia is thought to be technically feasible within about a decade.

However, there are constraints beyond the technical. People will need to be convinced. Lawyers and insurance executives may set the rate of change rather than technologists. This could lead to some surprising outcomes. Countries with a less litigious tradition than the USA may take the lead.

In our view, existing infrastructure will be surprisingly durable. The London Underground, for example, has developed over a 150-year period at huge expense, and is simply not going to change rapidly. In essence, the weight of deployed capital inhibits innovation. So stand-alone solutions that are cheap to get moving will evolve fastest and therefore have the greatest early impact. In our view, 'the rate of change is inversely proportional to capital expenditure'. Think of city bike schemes versus high speed rail lines.

The opportunities to create a better and more sustainable world seem almost endless. But people's behaviour is not so easy to forecast. For all its promise, General Motors' Firebird IV was consigned to history's dustbin. But that same year, Ford's Mustang launched, and it appealed to a more basic urge. This 'muscle car', was of course wildly successful.

One lesson here is that while the benefits of new technology can be huge, any novelty that promises efficiency at the expense of fulfilling some deep human need - freedom or control, say - will quickly rub up against the reality of human decision-making. It remains as hard as ever to know how we will all react and adapt.

For instance, while personal transportation represented 'freedom' to baby boomers, it is more commonly associated with selfishness, cost and hassle among Urban Millennials.

"We are witnessing a revolution in the transport industry, driven by a revolution in information technology. "



"The more we think about driverless vehicles, the more possibilities open-up."

We may therefore see transportation getting a 'cloud-web-surf' style make-over. Perhaps the old-fashioned word, 'auto', could be elegantly revived.

What about the transitional period of 'autos' sharing the road with 'toads' (driven cars)? To achieve the biggest benefits of automated driving (safe, high-speed travel), all cars will need to be driverless, resulting in an increasing push to get the 'toads' off the roads.

The economic model to attract sufficient early adopters for driverless cars remains unclear. Some propose in-car entertainment as the payment model: instead of driving, you are surfing the net, viewing online advertising, and therefore advertisers and paid-content providers will pay for the journey to connect with their audience. For now, the numbers don't add up. (Recently-listed Snap anticipates making just US \$20 per user by 2020.) On the other hand, the 'auto' will certainly be positioned to harvest huge amounts of human data. The OECD predicts 2.5 billion cars worldwide by 2050, with much of this growth coming from China and India.

We believe that a more likely model is one of asset-sharing. After stripping out the cost of an Uber driver, and then the cost of insurance (as accident rates fall towards zero and the combustion engine is replaced by solid state systems), the incremental cost of a taxi journey plummets. And if you aren't driving, then owning a car – paying for "the ultimate driving machine" – becomes a hollow experience.

With affordable and ubiquitous car-ferries, the distinction between public and private transport could fade.



The more we think about driverless vehicles, the more possibilities open-up. Suitcase-sized cars to transport personal effects? Shoe-box sized cars to replace couriers? Why sleep in your house, when you can sleep in your car and set your alarm to wake up as the 'auto' pulls into work? And that's before one considers the advent of the third-dimension - upwards! While flying cars seem to be an altogether more fantastic concept, the biggest obstacle in all this was always intelligence. Without down-playing the still considerable computer science problems to achieve all this, what we are witnessing is a revolution in the transport industry, driven in turn by a revolution in information technology. As the Economist recently wrote, "Data is to this century what oil was to the last one."

"While flying cars seem to be an altogether more fantastic concept, the biggest obstacle in all this was always intelligence."

Is this a sustainability investors' dream? We remain ever mindful that the path of innovation is not linear and never obvious. Viewing the world through the lens of sustainability guides us towards innovations of fundamental and lasting value. Technological advances in electrification, autonomous driving and the smart city will be incredibly disruptive. Let's explore them in more detail. Clever, clean, connected vehicles are just the beginning.

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# Electrification

The convergence of several major technological trends means that the cars of tomorrow will transform our lives and our environment. Arguably the most road-ready of these is electrification.

Electric vehicles still constitute a small proportion of new car sales (in most countries its less than 2%, although Norway is an outlier with 29% new cars sales being electric), but there is clear consumer appetite that will only increase as battery technology makes EVs competitive with internal combustion engines. This now looks likely to happen fast.

The cost of batteries has fallen 80% in the past six years, to an average of \$230/kWh for a complete battery pack. This is predicted to fall to \$100/kWh by 2025, a point at which cheaper long-term running costs will mean EVs are likely to quickly displace gas-guzzlers. (The electric motor is 90-95% energy efficient, compared with less than 20% for internal combustion engines.)

Electric cars currently account for 0.03% of Europe's total energy consumption, but by 2050, could account for 9.5%, based on an 80% share of EVs, according to the European Environment Agency.

Overall this seismic shift in 'under the hood' technology will of course most profoundly affect the automotive industry. Car makers have spent recent decades outsourcing virtually everything except the internal combustion engine and transmission.

And in contrast to many mechanical moving parts, solid state systems and electric motors will require far less maintenance – up to half of vehicle maintenance is attributable to the internal combustion engine. So, the vehicle maintenance and inspection industry, is likely to shrink and become highly specialist, with more focus on bespoke battery systems, and computer science.

Now let's remove the driver.

"Up to half of vehicle maintenance is attributable to the internal combustion engine."



## Fuel for thought #1: energy industry disruptor

Vehicle electrification will be a major disruptor of the energy industry.

First there are the geopolitical consequences and environmental benefits of fossil fuel elimination in transport, which will surely deserve a chapter in any history of the 21st century. Then there is the distribution efficiencies: electrons are much easier and cheaper to transport than bulk liquids (i.e. petrol and diesel).

At a more structural level, electric vehicles will contribute to the move towards a global 'Energy Web' where an interconnected and intelligent network will push electrons to places of our choosing, much like the internet, but at scales ranging from those used for information (tiny) to those used to move and heat things (cars being one example). (See our earlier paper, 'The Consequences of Renewables'). Vehicles then become portable power storage units that can both charge and discharge energy back into the system depending upon demand - making the grid more reliable, not less.

## Fuel for thought #2: who needs roadside?

Depending on how you count them, internal combustion engines have hundreds or even thousands of moving parts. Electric cars typically have about 20. With so much less to go wrong or wear out, the maintenance costs of electric cars are expected to be less than a third of ICEs.

On the other hand, today's batteries are expected to run for about 100,000 miles before they start to lose their inter-charging range capacity. Depending on how fast the cost of new batteries falls, this is likely to be a trigger for car renewal.

# Autonomy

## Telensa



**The business:** Telensa

**Founded:** 2005

**ETF Investment:** December 2015

### CITIES OF LIGHT

This Cambridge-based internet of things pioneer and world number one in smart street lighting solutions is using its existing infrastructure to provide low-cost traffic analytics across whole cities. In addition to gaining an ultra-local understanding of traffic patterns, cities can reduce energy costs by up to 30% through traffic-adaptive street lighting.

Driverless technology is both nascent and potentially transformative. There remain many multi-disciplinary challenges to solve to make full automation (known as Level 5) a reality – from imaging and sensory hardware, through to mapping, communications modules, and security. Whether you predict these problems will be solved in a few years, or a decade or so, the question is now ‘when’, not ‘if’.

For the automotive industry, the shift to driverless cars will require a fundamental reimagining of their product offering. We will see new entrants following Google’s trail. If the driving ‘experience’ is removed, then what might the main selling point be? The operating systems? (Think iCars); affordable comfort (IKEA cars?); or entertainment (Netflix cars?). Indeed, of 30 applicants for autonomous vehicle testing permits in April 2017, 11 were not incumbent car companies or their suppliers.

Whatever the tech challenges, the adoption of driverless technology is unlikely to be as smooth or fast as recent consumer electronic experience might suggest. For one thing, there is the coordination problem - the main benefits of driverless cars are derived only when a critical mass of cars are ‘autos’ not ‘toads’. Regulation can be useful to get the final few stragglers away from the steering wheel, but it is marketeers, appealing to the human psyche, who will need to do the heavy-lifting.

# Enabling the Smart City



**The business:** Vulog

**Founded:** 2006

**ETF Investment:** September 2015

## DISRUPTION OF SERVICE

Book a car, unlock it and drive away using your phone. Then leave it anywhere in a determined zone.

It's the future of city mobility and Paris-based Vulog has the software to make it happen.

We believe the greatest theatre for disruption will be cities. Three billion humans live in cities, a figure set to double by 2050<sup>1</sup>. Will they be gridlocked, frustrated asthmatics? Or will they enjoy zero-impact effortless transport through greenery and urban wildlife? The truth is likely to be somewhere in between, and the mobility revolution offers the prospect of transforming the quality of life in cities for the better.

Fully electric vehicles produce no direct emissions at point of use, radically improving air quality. Electric vehicles run virtually silently. Computer-driven 'autos' will not require traffic signals or physical warning signs. There will be no need to spend money on the ugly roadside furniture that litters developed cities. Driving patterns will change radically, with autos requiring minimal separation or lanes. Cars will not need to endlessly circle to find a parking place. With full 'Level 5' automation, car parking could be removed entirely from city streets, allowing more space for pedestrians, buskers – and who knows, even grass. Parking wardens and wheel clampers will go the way of crossings-sweepers (but that will do little to off-set the huge sums lost by local and city councils from parking fares and fines.)

Precisely how cities will exploit this mobility revolution is likely to depend heavily on the type of city, its affluence, population density and existing infrastructure. The imperial boulevards of Paris present different opportunities to the medieval lattice work of London, the sprawl of Los Angeles, or the density of Mumbai.

<sup>1</sup>) United Nations Human Settlement Program

# The sweet spot for investors

## WORLD SENSING



**The business:** Worldsensing

**Founded:** 2008

**ETF Investment:** July 2017

### REVOLUTIONISING MOBILITY MANAGEMENT

Worldsensing works with over 200 customers across 50 countries, connecting systems, people and infrastructure giving real time information to optimise city traffic flow and parking operations. In Bogota their work is reducing pollution, costs and saving lives as emergency response times fall. In Barcelona the average 45 minute journey into the city by car could be reduced by at least 7 minutes - saving the annual carbon emission equivalent of a forest four times the size of the city itself.

Why invest in brawn, when you can invest in the brain? We see three waves of change, underpinning the move towards the electrification of vehicles.

In the first wave, the pioneers simply looked at existing cars and powered them differently. In essence, they aimed to replicate existing car companies, which was an extremely expensive undertaking. It also meant taking on the well-capitalised incumbents directly. As a result nearly all the early start-up electric car companies failed. Most early investors in this first wave of investing lost all, while a few fortuitously backed the lone success which was able to raise huge sums: Tesla.

The first wave of investment in innovation created the need for a second; funding the roll-out of enabling infrastructure. Most obviously, battery charging infrastructure was needed, not to mention Giga factories for manufacturing the batteries. A key characteristic of this second wave was again its huge capital requirements, but also (at least initially) limited ability to differentiate the commodity produced. As a result this second wave was also difficult for venture capitalists (rather than infrastructure funds) as the returns on capital employed are not high.

The wave that interests us as venture capitalists is the third wave. Once there are electric vehicles, and it is clear that the market is growing, and once infrastructure begins to emerge, new needs and opportunities also appear.

In this third wave, 'smart' capital, rather than balance sheet capital, is needed to support entrepreneurs in building differentiated businesses that meet new needs. This is where we look for opportunities.



And opportunities abound, typically where knowledge or intelligence is at the heart of the offering. Take smart city internet of things pioneer, Telensa, whose smart streetlight-based traffic analysis enables cities to understand hyper-local congestion trends **and** reduce streetlight energy costs, while operational intelligence leader, Worldsensing, delivers real time, actionable insights from thousands of sensors and a mobility solution for cities to optimise operations, reducing congestion, pollution and emergency service response times. Or Vulog, another global leader, that takes

car sharing to the next level, by enabling borrowed or hired cars to be used for single trips and left anywhere when the trip ends – ‘free-floating’ trips. Interestingly, just as we focus on the ‘connected car,’ another company in our portfolio, Perpetuum, enables the ‘connected train,’ transforming rail safety and efficiency through wireless condition monitoring. Investing in intelligent, enabling systems and services is, we think, a ‘sweet spot’ that delivers huge value from the prior waves of infrastructure investment. In the process it is also delivering what we call ‘Sustainability through Innovation’.



# How green a future world?



A smart transportation network, underpinned by advances in the electric vehicle, autonomous driving and the smart city is not a utopian vision but an achievable goal. However, in the interim, radical changes in behaviour are bound to introduce complexity, confusion and potentially counter-productive outcomes as we grapple with change.

Seventeenth century diarist Samuel Pepys twice noted being stuck in horse and carriage traffic jams in London. Today, average car speed in Central London is below 8mph, slower than horse drawn carriages. The widely-understood lesson is that growth in capacity feeds demand. Whether your wheels are powered by oats, petrol or electricity, that won't change. Add to that the ability to send cars out on errands without human drivers, combined with a sky darkened by corporate delivery drones, and the serene cityscape of the future could look more like Blade Runner than some of us would care to imagine.

Such concerns are not a reason to halt progress – and indeed history says they will not – but they are opportunities for smart entrepreneurs. Entrepreneurs who will create solutions to enable a revolution that will bring about huge benefits. The introduction of technology is never enough on its own, as society needs to harness these breakthroughs to create a better, greener world – delivering what we call 'Sustainability through Innovation'.

The great game is afoot and billions are being spent to find the solutions. Yet the road to successful innovation is rarely a straight line. As investors in sustainability through innovation, we travel down some little-known side streets and into exotic avenues. What we discover there is unique and inspiring. For us, that is comfortable territory. We prefer the road less-travelled; our destination: deep, fundamental advancements in technology that enable a smarter, more efficient, more connected world.

## Fuel for thought #3: the e-Bike menace

Rolling luggage was invented in 1970 but not widely adopted for decades. The inventor, Bernard D. Sadow, attributes this delay to machismo. He was told that 'real men would want to lift their own luggage'. (Others say it was down to the relative ease of curbside drop-offs, or an abundance of luggage porters). These days almost every suitcase has wheels, and one unforeseen consequence is that travellers carry heavier bags.

Today, cynics say real cyclists won't ride e-bikes. Maybe not, but most other people will. Electric bikes are one of the untold stories of the transportation revolution. 'Real people' want to go further, faster, and see 'e-bikes' as a real alternative to traditional modes of transport. As we say above, the rate of change is inversely proportional to capital expenditure, and e-bikes are relatively cheap, so it is not surprising that there is an e-biking bonanza.

They are so popular in China, where there are already 200 million on the road, that several Chinese mega-cities are banning them. The problem is that they fall under bicycle regulation and have become a menace to pedestrians. A classic case of unintended consequences and the need for regulation to keep pace with innovation.

## Fuel for thought #4: motor insurance - whiplash

If you really want to understand the impact of vehicle innovation, the motor insurance industry is an interesting place to look. What seem like small, incremental changes to most of us, can have a big overall impact on risk.

For instance, even now, before the advent of automated driving, cars are much safer than they used to be. Sophisticated front and rear parking sensors mean bumps and scrapes are becoming rarities. In the medium term, the rise of telematics should allow insurers to provide a more adaptable and tailored product, measuring risk in real time and lowering or raising costs during the life of policies.

However, with the advent of entirely autonomous, 'Level 5' autos, the question is: 'who is the customer?' Perhaps it is the manufacturer, or the software provider?

Who decides, for example, that your car should hit a tree head-on, with more damage to you, if it avoids a glancing blow with a school-bus, so as to protect its passengers? Suddenly ethics are on centre stage, with lawyers attached. In the UK alone, the motor insurance industry manages \$0.8 trillion (that's a quarter of the UK's total net worth) and pays nearly 12 billion in taxes - and it will probably change completely.



**Sustainability through Innovation**

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