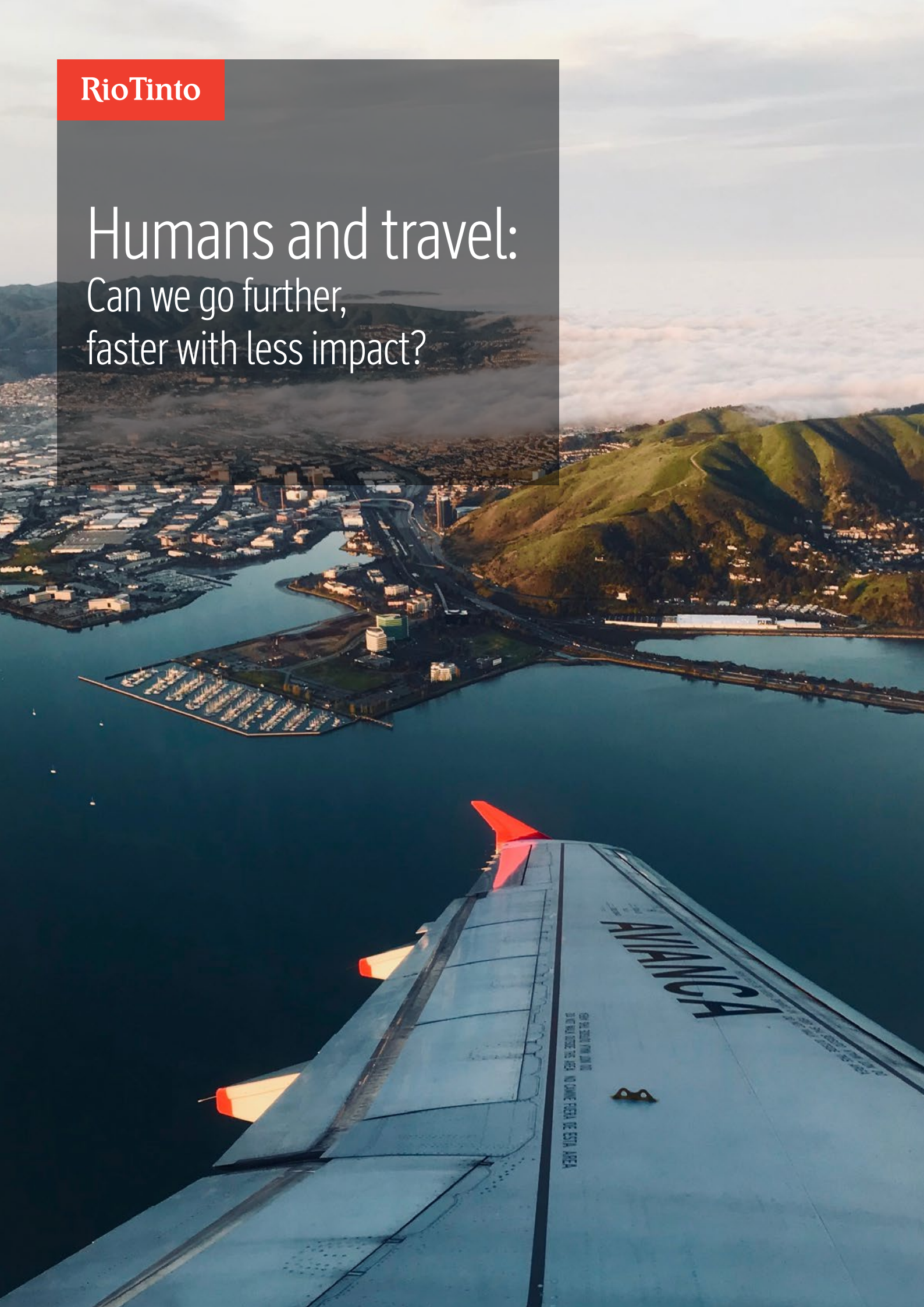


RioTinto

# Humans and travel: Can we go further, faster with less impact?



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# Foreword



Rio Tinto's pioneering use of technology, cross-sector partnerships and investment in the materials of the future are essential to human progress in travel.

The way humans travel around the globe and urban areas will need to change considerably over the coming decades. We are growing in number, yet we expect to be able to travel when and where we want at a reasonable price. We also care about the impact our movements have on the environment.

*So, can we go further, faster with less impact?* Advances in autonomous travel, new propulsion systems, alternative fuels and lightweight materials are definitely on track to make this possible. However, it's also going to take greater cross-sector collaboration and new ways of thinking about travel.

All industries have a stake in this progress. We all need to move people and products around the world in an efficient, safe and cost-effective way. This means regulators, policymakers, engineers and businesses need to share knowledge and work to create an environment in which new technology can function properly and sustainably.

The mining and resources industry relies on being able to move materials vast distances across land and sea. Transport makes up significant expenditure. This creates an

incentive to pioneer innovation in transport technology and operations that can later be adapted to commercial travel. Our partnerships with universities, start-ups, governments, communities, transport and other companies allow us to test state-of-the-art technology such as automation in the mines and between our facilities to boost safety and efficiency.

The industry also needs to work closely with manufacturers to supply the materials of the future. Lightweight, low-CO<sub>2</sub> aluminium and carbon fibre composites used to make the next generation of planes and vehicles, lithium to power electric batteries and LNG to power low-emissions ships will be needed to sustain our travel needs into the future.

However, innovation in travel will only come if we, as humans, change our behaviour. For the sake of convenience and cost, we will need to consider shared, on-demand and autonomous transport services. We're entering a new era of mobility and, at Rio Tinto, we see it as our responsibility to remain at the forefront to allow this progress to occur in the safest and most sustainable way.

We trust you will enjoy this article series that explores the change occurring to travel on land, sea, air and in space, and the opportunities for mining and metals to help humans travel further, faster and with less impact.

## Joanne Farrell

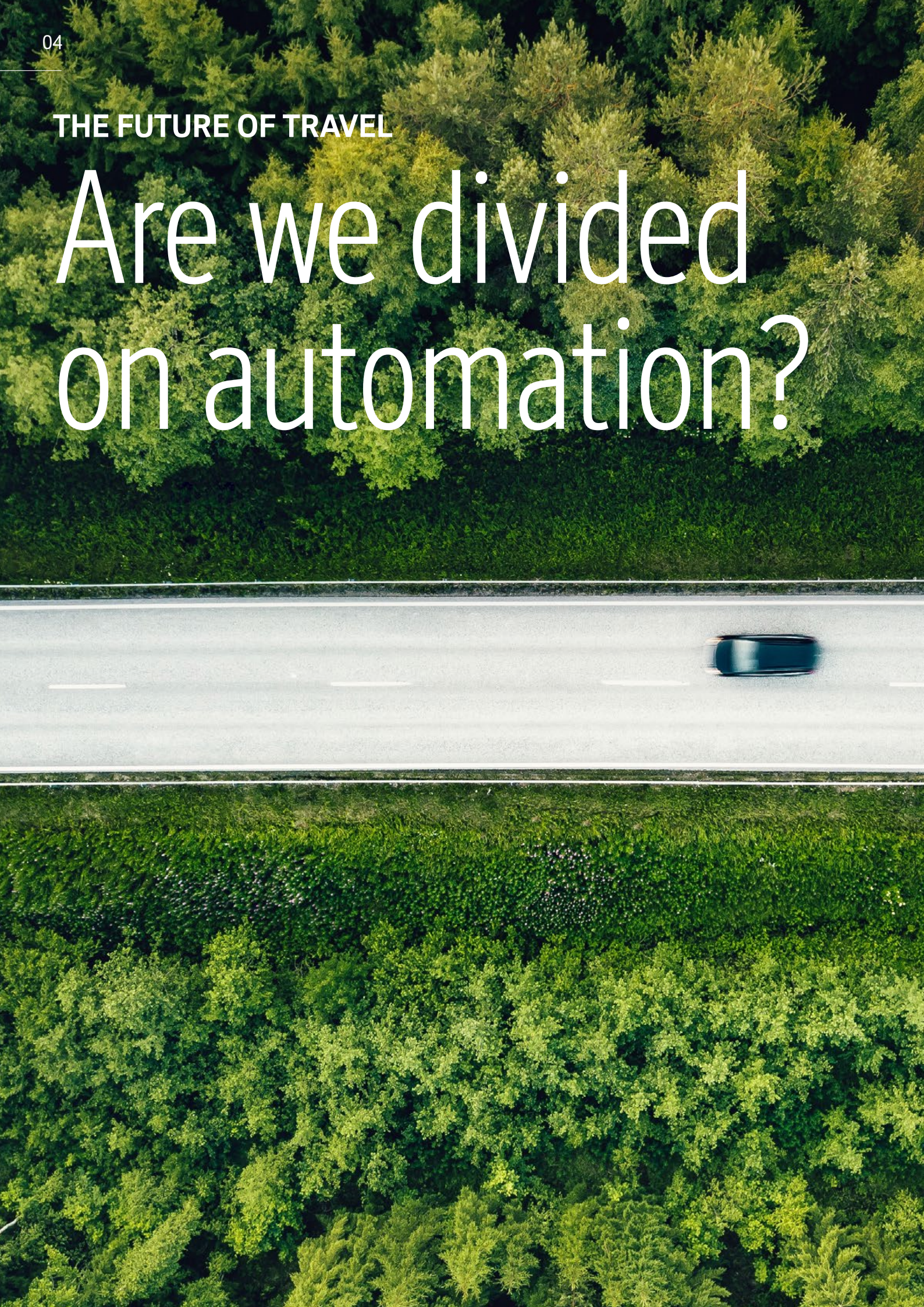
Group executive HSE and managing director Australia, Rio Tinto

January 2019

“Innovation in travel will only come if we, as humans, change our behaviour.”

THE FUTURE OF TRAVEL

# Are we divided on automation?



“It’s like asking people if they wanted an iPhone before it was launched. People are judging something with which very few have experience.”

– Jan Hellåker, program director, Drive Sweden

Automation has the potential to shake up land, sea, air and space travel like no other technology in the next 20 years. Lessons from the use of automation in industry can help us learn to trust it in our everyday lives.

Our cities are becoming more congested, yet we still want to travel faster, cheaper and whenever we want to. For this to be possible, we need new technology, widespread collaboration and a new attitude to travel.

This new attitude means sharing cars or rides with others to get vehicles off the roads and booking transport only when we need it to cut down costs and time. It also means eventually giving up the driver seat to an automated machine. The problem is we’re not quite ready to give up control.

According to the recent Rio Tinto *Future of Travel* survey conducted in Australia, the public ranks the development of autonomous or driverless vehicles extremely low in terms of transport priorities. In fact, 40 per cent say it is ‘not a priority at all’. Just over half of people say driverless cars will never address their concerns about safety.

Jan Hellåker believes people don’t yet understand the full benefits of the technology. He is the program director of Drive Sweden, a ground-breaking initiative to bring together people from a range of sectors to progress driverless vehicles and the new era of mobility.

“It’s like asking people if they wanted an iPhone before it was launched. People are judging something with which very few have experience,” he said.

“We provided a couple of driverless shuttle buses in Sweden last year and asked people before they boarded and after disembarking how safe and secure they felt. We went from about 80 to over 90 per cent who felt safe and secure.”

A big part of convincing the public that driverless vehicles are safe and should be a priority will be seeing their successful use in other industries such as mining and resources. Rio Tinto has been working with the University of Sydney for a decade to build its Mine of the Future™ showcasing autonomous technology.

In Australia, the company has been using driverless trucks for 10 years, launched the world’s first driverless train in 2018, and plans to have 20 automated drills working at five different sites.

“We’ve learnt some really important lessons about autonomous vehicles. We’ve dealt with speeds, collision avoidance, obstruction, level crossings, complexities of weather and terrain. This lays a solid foundation for their use in everyday life.”

– Stephen McIntosh, group executive – Growth & Innovation, Rio Tinto

Stephen McIntosh, who heads up innovation at Rio Tinto, says mining automation has had a huge impact on efficiency, flexibility and safety.

“The Pilbara train is the world’s largest robot and longest heavy haul train. It’s a really amazing piece of engineering,” McIntosh said.

“We’ve learnt some really important lessons about autonomous vehicles. We’ve dealt with speeds, collision avoidance, obstruction, level crossings, complexities of weather and terrain. This lays a solid foundation for their use in everyday life.”

Some experts believe autonomous transport will free up our roads, cut waiting times and create more public space where carparks and other infrastructure is no longer needed. But most importantly for the public, they say driverless vehicles will mean fewer accidents and be much cheaper to run.

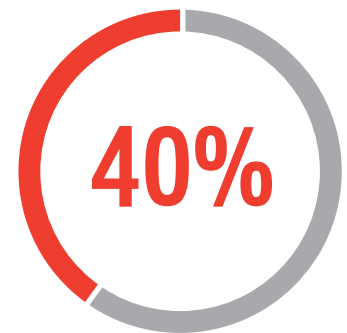
Hellåker says this is all possible but only if we start filling the driverless cars with more people.

“I think it’s safe to say the more self-driving vehicles we have, the safer the traffic will be, but we need to increase occupancy in these vehicles,” he said.

“With on-demand driverless vehicles, there won’t be a need for everyone to keep having one or more vehicles per household.”

McIntosh agrees that the safety case for autonomous vehicles is strong.

“In our industry, we have an obsessive focus on safety. It’s an inherently dangerous work environment. Safety improvements we are seeing from autonomous trucks, trains and drill rigs could put us on a path to eliminate fatalities at work in my lifetime,” he said.



of Australians say the development of driverless vehicles is ‘not a priority at all’



Improving safety is the number one transport priority for the public

## Is Australia set up for driverless vehicles?

The case for driverless vehicles in Australia will soon be much stronger. Geoscience Australia is rolling out a new national satellite positioning system, which will improve GPS accuracy to within 10 centimetres compared to the five to 10 metres we have today.

John Dawson is managing the landmark project and says the GPS upgrade will make autonomous transport in Australia possible.

“In the future, there will be cars in automated mode passing each other in different directions and they will need to know the location of that car to within 10 and 20 centimetres. Our current GPS network simply doesn’t enable this application in autonomous transport,” he said.

In 2017, Geoscience Australia became the first in the world to test the next generation GPS technology across 10 different industries including mining, aviation and maritime. It now has close to half a billion

dollars over 10 years to implement it. A parallel program will improve GPS accuracy to three centimetres in mobile coverage areas.

“There’s a whole range of regulatory challenges and impediments to automation across the transport sectors. But, in terms of technology, we will have an infrastructure that’s ready for those applications,” Dawson said.

By 2020, regulation will also catch up when a new national law developed by the National Transport Commission is due allowing driverless cars, buses and trucks to operate on Australian roads.

These proposed changes will keep Australia close to countries like Sweden, the USA and China where driverless cars and buses are already being tested in urban environments.



Rio Tinto's AutoHaul™ autonomous train is the largest robot in the world and will help guide the development of driverless trains for people. Source: Rio Tinto

LAND

# Is Australia's transport revolution stalling?





“The sooner we have the market for electric vehicles here in Australia, the sooner we get on with generating innovative new businesses and the jobs for the future, because we know some of the jobs of the past are going to dry up.”

– Behyad Jafari, CEO, Electric Vehicle Council



Electric Vehicle Council CEO Behyad Jafari says Australia is becoming a dumping ground for less efficient cars while the rest of the developed world turns to electric vehicles. Source: Rio Tinto

Electric cars are proving a hurdle for Australia in the transition to a new age of mobility. Greater intervention and access to new materials will help propel the industry and bring more affordable models to our shores.

Australians love their cars. We bought around 400,000 of them last year alone, according the latest Motor Vehicle Census. Yet, we're one of the slowest adopters of electric cars in the western world.

While this might not concern most Australians, experts say we're missing out on one of the biggest transport transformations of our time as a result.

The Electric Vehicle Council is determined to make sure Australia doesn't miss the public health, environmental and economic benefits that come with the move to electric cars. The Council's chief executive officer Behyad Jafari says Australians are usually early adopters of new technology, so the barrier is political rather than cultural.

“Australia is in the lowest group of uptake among all developed countries. We haven't had much regulation around vehicle efficiency yet. That's why, for decades now, Australia has been a dumping ground for less efficient vehicles,” he said.

“The sooner we have the market for electric vehicles here in Australia, the sooner we get on with generating innovative new businesses and the jobs for the future, because we know some of the jobs of the past are going to dry up.”

Jafari says the solution to the problem is simple. We need to prove to vehicle manufacturers that we are serious about electric cars through government intervention and remove the barriers for consumers.

We can see this working in other parts of the world where countries have set carbon-reduction targets for cities and car manufacturers as well as introduced incentives for consumers and companies to go electric.

Similar strategies are starting to be adopted in Australia. In the last two years, both the ACT and Queensland released action plans to shift to electric vehicles. They plan to introduce financial incentives for purchasers, invest in charging infrastructure and switch their government fleets over to electric.

In the recent Rio Tinto *Future of Travel* survey, two-thirds of Australians predicted most cars would be electric within the next 20 years but said the initial cost was the main reason preventing them from buying one.

Bloomberg's Electric Vehicle Outlook 2018 predicts electric vehicles will increase from 1.1 million worldwide in 2017 to 30 million in 2030 as they become cheaper to make than petrol and diesel cars. For this to become a reality, the world is going to need greater access to the materials used to make them.

Stephen McIntosh who heads up innovation at Rio Tinto says they have been watching the transition to electric cars for some time and preparing for big changes.

"This transition to electric cars is already happening around the world and we'd expect to see this flow through to industrial machinery. You only need to look at China to see the possibilities for the technology. These countries leading the way are actively building the electric car industry to reduce carbon emissions and congestion," he said.

"It will reach Australia eventually and we want to be ready."

Rio Tinto is expanding its focus beyond its current commodity portfolio to look at lithium and nickel used in batteries as well

as its existing products of aluminium and copper used in the wiring and bodies of the vehicles to meet demand in China and other leading markets.

"One of the things we're looking at very carefully is how we can actually supply into the de-carbonising world, the minerals and metals that will drive electric vehicles," McIntosh said.

"Australia is becoming an important producer of lithium, so the electric vehicle market presents a big opportunity for the country on more than one level."

Rio Tinto hopes to start mine construction at one of the largest lithium deposits in the world near the town of Loznica, Serbia, as early as 2020. It is also running trials of electric vehicles in the mines to improve the air quality for employees and to reduce its carbon footprint.



Two-thirds of Australians believe most cars will be electric in 20 years' time



Jadar in Serbia is one of the world's largest lithium deposits, which will supply electric car manufacturers into the future. Source: Rio Tinto

### Global electric vehicle sales targets:

|                    |                    |
|--------------------|--------------------|
| <b>India</b>       | 30% by 2030        |
| <b>China</b>       | 35m (20%+) by 2025 |
| <b>Germany</b>     | 1m by 2020         |
| <b>Norway</b>      | 100% by 2025       |
| <b>Netherlands</b> | 100% by 2030       |
| <b>UK</b>          | 60% by 2030        |
| <b>Japan</b>       | 100% by 2050       |
| <b>New Zealand</b> | 64,000 by 2021     |
| <b>California</b>  | 5m by 2030         |
| <b>Australia</b>   | no targets         |



A Tesla™ showroom has opened in central Sydney. Source: Rio Tinto

## What happens after electric cars take off?

One reason for the focus on the electric vehicle market in Australia is its potential to kickstart the new era of mobility, which will see people owning fewer cars, sharing rides, driving less and getting around emissions free.

“Electric cars are the gateway to everything else,” Jafari said.

“What we are seeing in the rest of the world is that, after your electric vehicle market starts to take off, you see more shared mobility options because the economic business case for them stacks up.”

Jafari is referring to car-sharing and taxi businesses being able to grow their fleets and improve their service because of the lower operating costs of electric vehicles, making car ownership less of a necessity. On top of that, the driverless capabilities being developed for new electric models mean fewer people will need to drive and even get their licence.

Drive Sweden is a ground-breaking initiative bringing together policymakers, regulators, city planners, manufacturers, academics

and others to facilitate this transition in a sustainable way. Its program director Jan Hellåker says the new era of mobility will change our relationship with the car forever.

“For about 100 years now, the privately-owned car has been the most coveted asset that we have, but the younger generation is not as keen on owning things as my generation. They’re more interested in having access to a service when they need it. You can see that happening in a number of areas such as music,” he said.

General Motors chief executive officer Mary Barra summed up the benefits of electric and autonomous vehicles to investors in December 2017 as “zero emissions, zero crashes, zero congestion”. But for this vision to come true, Hellåker believes we need to change the way we think about travel before we adopt the technology.

“The idea that all cars would be driverless tomorrow morning concerns me,” he said.

“Imagine you have a fully driverless car. You would be able to continue breakfast in your car or sleep or start working so the incentive of not sitting in traffic would go away, which could fill up the roads in a heartbeat. Unless we start filling those cars with more people, we won’t see a difference.”



The initial cost is the number one barrier to using electric cars

AIR

# Are we prepared for the aviation boom?



“The current flight time between Sydney and Melbourne is an hour and a half, so we don’t think twice about a day trip. If that flight time increases because we can’t land the increased number of planes, people won’t do it.”

– Jason Harfield, CEO, Airservices Australia

Aviation is amid a flurry of innovation to get ready for twice as many passengers in the next 20 years. It could mean a new golden era of air travel.

As passenger numbers soar to around 7.2 billion by 2035, the aviation industry is faced with the incredible challenge of moving twice as many people, more often and with less of an impact on the environment.

On top of this, the expectations of air travellers are changing. Around one-third of people expect to be able to book air travel on demand in the next 10 years and travel from Sydney to London in less than 12 hours in the next 20 years, according to the recent Rio Tinto *Future of Travel* survey.

To pull this all off, everyone from traffic controllers to materials manufacturers will need to be prepared so the growth and innovation can happen in a sustainable way for future generations.

Airservices Australia, which manages 11 per cent of the world’s airspace, has already begun to transform its air traffic management system to cope with the rapid change. Its chief executive officer Jason Harfield says if the foundations are not put in place now, it will have ramifications for the industry down the track.

“The current flight time between Sydney and Melbourne is an hour and a half, so we don’t think twice about a day trip. If that flight time increases because we can’t land the increased number of planes, people won’t do it,” he said.

“We’re an industry that is being heavily disrupted, so we need to change and evolve with it to deliver on our mandate to keep the skies safe.”

In preparation, Harfield and his team are delivering OneSKY Australia™, a single platform for Australia’s civil and military air traffic management systems, which is designed to save airports, airlines and others time and money while improving safety.

If they do their job well, Harfield says travellers shouldn’t notice a difference to their service despite the jump in passenger numbers.

“The work we are doing should make your life seamless. In the future, you will be able to get an Uber Elevate to the new Western Sydney Airport and get on a flight in one of the busiest air spaces in the world, and you won’t think twice about it,” he said.

The world’s largest aircraft manufacturers Airbus and Boeing are also adapting. They’re ramping up operations after each selling close to US\$100 billion worth of commercial aircrafts at the recent Farnborough International Airshow in the United Kingdom. They’re also focusing on new lightweight



The view of the runway from Melbourne Airport tower. Source: Airservices Australia



Aerospace engineer Ed Muthiah wants to see a greater focus on the whole lifecycle of technology so the growth in the industry is sustainable.  
Source: Australian Youth Aerospace Association

materials like aluminium and carbon fibre composites that are proving important to cheaper, more fuel-efficient travel.

Carbon fibre composites are flexible, lightweight materials that don't corrode or age as quickly as other metals, meaning they need less fuel to propel them and less maintenance. They were used to make up nearly half of the frame on the new Boeing 787 Dreamliner™, which is about 20 per cent lighter than traditional designs.

Carbon Nexus research and innovation leader Maxime Maghe is one of the world's experts in developing economical carbon fibres. Based in Geelong in what he calls the "Silicon Valley of carbon fibres", he believes the technology will play a vital role in the next generation of transport.

"All transport sectors are being pushed to reach certain emissions targets, but they also cannot compromise on performance. That's where carbon fibres come in," he said.

"The main barrier at the moment is cost. This comes from the fact that it is still a relatively niche market and that a special grade of carbon fibre with higher mechanical properties is required for the aerospace industry, which is costly to produce."

The mining and resources industry will be key to helping lower the cost of lightweight

materials by supplying enough for the growing aviation industry.

More planes mean more demand for the materials needed to make them. While this presents an opportunity for the mining industry, Rio Tinto Aluminium's Alf Barrios says it also means a greater investment in the science of new materials to help the aviation industry meet its ambitious efficiency targets.

**"Each generation of aircraft will require a new generation of materials. A doubling of the global air fleet in the next 20 years will not only rely on sustainably produced aluminium but also new composite materials," he said.**

Barrios expects Aluminium demand to rise by about four per cent over the next five years mainly because of its use in transportation.

"Aluminium has an amazing light weighting capability, so we can take weight out of trucks, trains, planes and other things," he said.

"Tomorrow's aluminium needs to be more efficiently produced with an ongoing focus on product stewardship backed by technology improvements throughout the production cycle."



of Australians expect to see on-demand air travel in the next 10 years and under 12-hour flights from Sydney to London in the next 20 years



Assembly of the first Air Mauritius A350 XWB with its state-of-the-art aerodynamic morphing wing at Airbus' Final Assembly Line in Toulouse, France. The aircraft is 25 per cent more fuel efficient than the previous generation aircraft. Source: Airbus

## What does the next generation think?

One of Australia's aerospace leaders of the future, Ed Muthiah, says it's an incredibly exciting time to be entering the industry but isn't sure whether we're ready as a society for such rapid growth.

As chair of the Aerospace Futures Conference, he is in close contact with the next generation of aerospace engineers. He says there's an onus on them to collaborate even more with regulators and policymakers across aviation and space to manage the growth in a sustainable way.

"As youth, it's hard to distance yourself from the exciting technologies and notice the vicious spiral of more people, more platforms," Muthiah said.

"If you think of everything above the ground in layers. There are drones that fly up to 400 feet, planes that fly at 35,000 feet, high altitude drones, low earth orbit cube-satellites and medium earth orbit navigation satellites.

"Congestion inside and outside our atmosphere shows no signs of slowing. We are focusing a lot on the 'what' and 'how' as opposed to 'why'."

He hopes the engineers of the future will look at design in a holistic way.

"Technology has for a long time been developing quicker than regulation can keep up. For future generations working on new technologies, the end of the lifecycle needs to be at the front of mind, as part of self-regulation to ensure that systems can be retired and recycled appropriately," he said.

SPACE

# Could Australia's late entrance be timely?





## “Australia has a unique advantage over traditional bureaucratic agencies established 50 or 60 years ago.”

– Ed Muthiah, chair of the Australian Youth Aerospace Association’s Aerospace Futures Conference

Australia is entering the global space industry at a time when private enterprise is driving innovation. All sectors are being called upon to help boost our country’s contribution.

The dreams of Australian companies and scientists came true in July last year when we launched our very own space agency. Some people think it was a long time coming, but others believe the late entrance could actually be an advantage.

It may have come at the perfect time as the global space industry shifts from the public to the private sector, meaning smaller companies and countries have the chance to do things in a more agile way than some of the more established space agencies.

Next generation aerospace engineer Ed Muthiah, who chairs the Aerospace Futures Conference, says joining during the new entrepreneurial space age, also known as Space 2.0, could give us a competitive edge.

“Australia has a unique advantage over traditional bureaucratic agencies established 50 or 60 years ago,” he said.

One of Australia’s brightest minds in the space industry and world expert on hypersonics Professor Michael Smart agrees we are in a good position to have a real impact on the global industry.

“We don’t have massive companies who are making lots of money by going to space in the traditional way. We can break in and be one of the disruptors, because we don’t have all that old-fashioned infrastructure built up in Australia. It’s definitely an opportunity for us,” he said.

The Australian Space Agency has also highlighted the benefit of joining the party late, saying it will be one of the most industry-focused space agencies in the world and will draw on homegrown talent and ingenuity to become a leader on the global stage.

The next step is deciding where Australia will shine. Megan Clark, who is on the Board of Rio Tinto, has been chosen to head up the new Agency. She is calling on Australian businesses to do their bit to advance the local industry as well as help themselves.

“Rio Tinto is developing autonomous drilling and that’s the sort of thing you will need to do on Mars and on the moon. While we’re drilling for iron ore in the Pilbara, on the moon they might be looking for basic resources to survive like soils, water and oxygen.”

– Megan Clark, head of the Australian Space Agency and non-executive director at Rio Tinto



Head of the Australian Space Agency Megan Clark says space travel is not a priority but Australian industry can make a big contribution to space exploration. Source: Kym Smith / Newspix

“We believe that what Australia is doing on Earth is of interest to space companies and, of course, as space companies work out how to operate remotely, then what they do is of interest to us,” Clark said.

The Agency has six priority areas that make the most of the country’s unique expertise and location. One of these is remote asset management used widely in the mining and resources industry, particularly in Australia.

Rio Tinto has autonomous drills in its mines in the Pilbara region in Western Australia, which are run from a control room in Perth 1500 kilometres away. The company is collaborating with the space industry to see how this and other mining technology could be used in space.

“Rio Tinto is developing autonomous drilling and that’s the sort of thing you will need to do on Mars and on the moon. While we’re drilling for iron ore in the Pilbara, on the moon they might be looking for basic resources to survive like soils, water and oxygen,” Clark said.

Another transferable technology from the mining industry is remote rovers. They are used to move materials around the rough terrain of mine sites similar to the surface of some planets.

Australian oil and gas company, Woodside, is also partnering with NASA to train a “robonaut” called Rick. The robot will transfer its skills used on the International Space Station to Woodside’s offshore oil rigs.

“You can absolutely see this theme of ‘on earth in space and in space on earth’ as being how Australia continues to lead and form partnerships that have never formed before. This is about each industry learning from each other,” Clark said.



The launch of the Hyshot 3 supersonic combustion flight on 26 March 2006. Source: University of Queensland



Chair of Hypersonic Propulsion Michael Smart at the University of Queensland hopes the Australian Space Agency will focus on the country's niche areas such as scramjet engines. Pictured here with postgraduate student Jens Kunze. Source: Rio Tinto



One in five people believe space travel should be a priority for Australia

## When can we travel to space?

According to Rio Tinto's recent *Future of Travel* survey, one in five people believe space travel should be a priority for Australia. Space tourism, research trips to the International Space Station, and even settlement on another planet are all possibilities down the track, but we're not there yet.

The truth is commercial space travel is not going to happen any time soon, or at least not at a price most of us can pay. Clark says Australia is looking into opportunities to participate on joint missions with other countries, but that sending Australian astronauts into space is not yet on the timetable.

The good news is the technology being developed today will make travel in space and on Earth easier, cheaper and better for the environment in the long run.

Scramjet engines are one of the technologies that could have a big impact, and Australia is leading the way. Unlike traditional rockets that need to store oxygen on board, scramjets breathe in air from the atmosphere as they move, making hypersonic rockets and aircrafts lighter, reusable and cheaper.

A hypersonic plane with a scramjet engine would not only be good for the environment, it would get us from Sydney to London in about two hours.

Michael Smart, who holds the Chair of Hypersonic Propulsion at the University of Queensland, is one of the world's leading experts on scramjet engines. He says they are currently testing the technology to launch satellites on a regular and reusable basis, but that companies in the United States are exploring how to combine the scramjets with jet engines to transport people.

"A scramjet engine is so simple, because there are no moving parts. It's all done by understanding aerodynamics. To develop a new scramjet engine, we're talking hundreds of millions of dollars instead of billions of dollars," he said.

He is hoping the Australian Space Agency will accelerate the development phase of hypersonic scramjets for both space and aviation.

"Australia is never going to be the best at everything, but we have some niche technologies, and hypersonics is one of them. For space, we have the most advanced scramjets of anybody," he said.

"If we stare at our navel for five years and try to come up with the best possible plan for the space agency, the opportunity will be gone."

SEA

# Who will lead the green charge?





Maritime Industry Association Limited CEO Teresa Lloyd says the public is calling for a greener industry.  
Source: Rio Tinto

“Protecting and preserving the environment is the right thing to do and it is fundamental to the long-term success of our industry.”

– Joel Katz, Australasia managing director,  
Cruise Lines International Association

The maritime industry has an opportunity to continue to push towards sustainability and drive demand for green ships, but success will depend on who jumps on board.

The seas are slowly turning green and many would say it's not a moment too soon.

Australians believe the environment should be top of the agenda for the maritime industry over the next 20 years, according to Rio Tinto's recent *Future of Travel* survey. Those surveyed said new ships should have a focus on fuel efficiency, renewable energy and resilience to climate change.

Eighty-one per cent also said the development of cleaner forms of fuel

for all forms of transport was essential or important.

This is a clear message from the public that it wants the industry to improve its environmental standards, which is understandable when you look at its size and footprint. The international shipping sector transports up to 90 per cent of world trade, according to the International Chamber of Shipping, and the US\$126 billion global cruise sector expected to service more than 27 million passengers in 2018.

Its biggest problem is that shipping is responsible for about 2.5 per cent of global greenhouse gas emissions. Teresa Lloyd, who is chief executive officer of Maritime Industry Australia Limited, says the industry has a big challenge ahead, because it is starting from a low benchmark.

“Over the years, ships have transitioned from sails to coal and, for decades now, most have relied upon heavy fuel oil, which is almost like the tar at the bottom of the refinery that they can't do anything else with. It's unusable except to make roads out of and it has a lot of environmental impacts when you burn it,” she said.

But change is on the horizon. The International Maritime Organisation (IMO) announced it will enact legislation requiring a 0.5 per cent cap on the amount of sulphur being emitted from marine fuel by 1 January 2020, down from 3.5 per cent today. In April 2018, it also set a target to reduce greenhouse gas emissions by 50 per cent from 2008 levels by 2050.

This is no small feat when you consider the cost of upgrading or replacing shipping and cruise vessels as well as the tight deadline

given to the industry to comply. But it's full steam ahead to get ready for the cap and potential future environmental regulations with pioneering companies already investing in new fuels, engine technologies and state-of-the-art ships.

"Progress is usually made very slowly and in very isolated instances to start with and, once they can test the concept somewhere, they might roll it out," Lloyd said.

This challenge is front of mind for Rio Tinto's vice president of Marine and Logistics Isabelle Brassard. The world's second biggest miner owns 17 of its own ships and charters more than 200 vessels at any time globally.

**"Ensuring vessels are safer in terms of operations and impacts to the environment is our first priority," she said.**

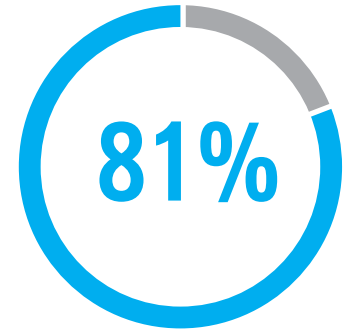
"From a shipping perspective, our position on the sulphur cap is clear: it is the right thing to do and we will ensure our vessels are compliant. The challenge is for the new regulation to be implemented in a fair,

consistent manner globally to ensure a level playing field for all industry participants."

There are a number of ways companies can try to meet the IMO's targets, but industry commentators say they are all expensive and come with their own risks. Companies can choose to switch to more expensive low-sulphur fuels, install "scrubbers" to clean emissions from ship funnels or invest in alternative fuels such as LNG, which emits up to 95 per cent less sulphur oxide and up to 25 per cent less carbon dioxide.

"This is a chicken and egg situation. The ships aren't going to burn LNG until they know it is going to be available and the LNG suppliers aren't going to make it available unless they know there's going to be a market for it. That's working its way through the system now," Lloyd said.

In January last year, Australian oil and gas company Woodside trialled an LNG-diesel-fuelled supply vessel called Siem Thiima to prove that the use of LNG was both technically viable and competitive. The next step is the development of a commercially-viable, dual fuel, LNG-powered dry bulk carrier to carry iron ore from the Pilbara to China.



of Australians rank the development of cleaner fuels for transport as essential or important

Top 3 public priorities for ship technology in the next 20 years:



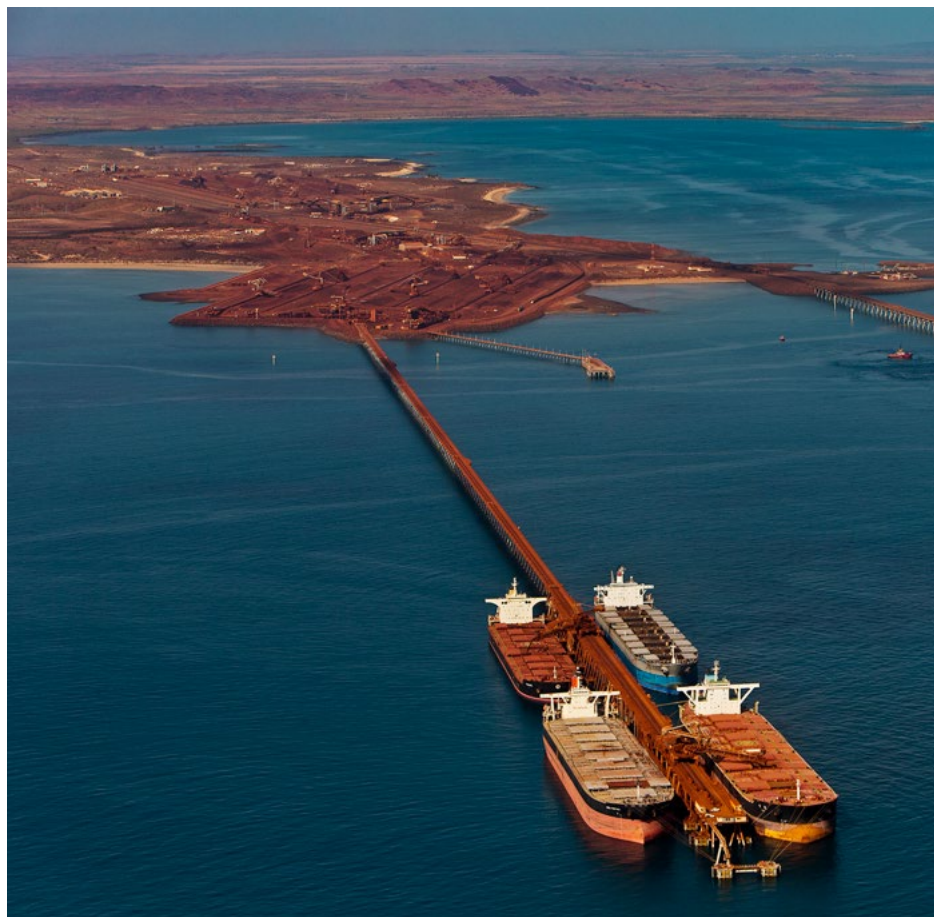
1. Improving the fuel-efficiency of ships



2. Developing ships powered by renewable energy



3. Preparing more resilient ships for climate change events



Rio Tinto ships at the Cape Lambert Port Expansion in Western Australia. Source: Rio Tinto



AIDA Cruises launched the first fully LNG-powered cruise ship, the AIDAnova, in September 2018. Source: AIDA

This kind of investment will increase the competitiveness of using LNG and may encourage ports to consider upgrades that will allow large LNG-powered carriers to refuel. In fact, upgrades to the ports at Fremantle, Dampier and Melbourne could be ready in two years.

The mining and energy sectors are also behind another sustainable shipping initiative helping to green the industry. The well-known safety quality vetting system called RightShip™ aims to push companies to seek out the most energy-efficient vessels to charter. It is driven by companies including Rio Tinto, BHP and Cargill Ocean Transport.

“This vetting system creates some transparency around the safety and environmental standards of the shipping industry and continuously pushes it to improve standards. Operating safely and efficiently drives strong business performance,” said Brassard, who also serves as chairperson of RightShip™.

## Will the green makeover attract new cruisers?

If the maritime industry succeeds in meeting the environmental targets, it might be able to turn around its reputation, spark innovation and boost cruise tourism.

Joel Katz, who manages the Australasian region for the Cruise Lines International Association (CLIA), says the focus on sustainability could be a big drawcard for the next generation of eco-conscious cruisers looking for sustainable tourism experiences, better recycling and waste management and more environmentally friendly ships.

“While only accounting for a small percentage of the overall maritime fleet, it is critical that the cruise industry collaborates with environmental stakeholders, develops clean technologies, and leads the maritime industry in the best environmental practices and policies”, Katz said.

“Protecting and preserving the environment is the right thing to do and it is fundamental to the long-term success of our industry.”

Seven cruise lines are currently building up to 16 cruise ships propelled by LNG. AIDA Cruises, owned by Carnival Corporation, launched the first fully LNG-powered cruise ship in September - the US\$1.1 billion AIDAnova.

Cruise lines are also investing billions in a range of environmental technologies from wastewater treatment systems and solar panels to new coatings for ship hulls and lightweight materials that will reduce fuel consumption.

With the green makeover well underway, cruises are becoming more popular, particularly among Australians. According to CLIA, more than 1.34 million Australians took an ocean cruise in 2017, 4.4 per cent more than the previous year. With the right infrastructure and policies, Katz expects cruise holidays to become a bigger part of Australian traveller culture.

The logo for RioTinto, featuring the company name in white serif font centered within a solid red rectangular background.

RioTinto

Disclaimer: This publication contains general information only in relation to the future of travel and the role of the mining and resources industry, it does not provide an exhaustive account of new and upcoming trends and/or technologies in relation to this subject matter. Its contents are based on a series of interviews conducted from July to September 2018 and the comments and opinions provided herein are those of the relevant interviewee only and not those of Rio Tinto. This publication is not a substitute for professional advice or services and it should not be used as a basis for any decision or action that may affect your finances or your business. None of Rio Tinto, its Related Bodies Corporate or its and their respective affiliates shall be in any way responsible for any loss (however arising) by any person who relies on this publication.