OLIVER WYMAN

VELOCITY

TRAVEL, TRANSPORT & LOGISTICS 2017

MARSH GUY CARPENTER MERCER OLIVER WYMAN

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TO OUR READERS

Welcome to the 2017 edition of *VELOCITY*, Oliver Wyman's annual journal on travel, transport, and logistics. We've updated the name of our journal to better represent the fast-changing nature of these industries today. This issue focuses on digital and technological innovations that are just beginning to make themselves felt – but that will certainly influence the development of multiple industries over the next decade.

Data in all its forms continues to be one of the big stories, as information flow increasingly becomes the world's currency. Digital disruptors are capitalizing on the vast accumulation of data to fundamentally change their industries. In travel, distributed transaction technology, known as "blockchain," could revolutionize loyalty programs. In logistics, digital startups are rising at a furious pace, impacting the value chain of large incumbents. And "meta-platforms" – massively wide, deep, and intelligent computing environments – are expected to drive rapid changes across the shipping spectrum.

Another headline from the future is machine learning, a type of artificial intelligence. In aviation, smarter avionics could help address the problem of crew fatigue. For asset-based industries, where assets themselves are generating a much wider array of data, models that incorporate machine learning are expected to become much better in the future at predicting maintenance needs.

Autonomous vehicles will be the most visible form of artificial intelligence in a few years – starting first with advanced driver assistance systems. Autonomous trucking for example, coupled with increases in trucking fuel efficiency, will challenge the rail freight industry to innovate both operationally and technologically. And that brings us back to data: As the role of the driver lessens, car and truck manufacturers, commercial fleet operators, and insurance companies will all need better data and analytics to refine their products and services and reduce risk.

Finally, the increasing role of digitalization and smart machines won't lessen the need for talented human beings to make all of this work. In this issue, we discuss the talent shortage in aviation maintenance and repair, but many traditional industries are already feeling the pinch to acquire the skills that will drive and support future growth.

We hope that you find this issue of *VELOCITY* to be a thought-provoking read, and we look forward to hearing your comments.

CONTENTS

Innovations

THE NEW, NEW ECONOMY: DATA AND EXPERIENCE

THE KIND OF ECONOMY that underlies the world's markets is once again in a state of flux. The goods economy, the services economy, the information economy – each in turn has given way to the next big thing. We are now seeing the rise of a "data and experience economy" – driven by the growing connectedness of people and the availability of digital technologies.

Information flow is increasingly the world's currency and open to a widening share of the world's population – 230 million new users are being added to the Internet each year. Data availability is supporting step changes in performance, return on investment, and sustainable development. For example, design virtualization is reducing aircraft time-to-market by 15 percent, while airlines have realized $30 billion in fuel savings over the past 15 years due to data-driven productivity improvements.

The consequences of this shift in economic drivers for every sector is massive, including travel, transport, and logistics. Agile companies that champion user experiences and efficiently exploit data to that end are the most likely to benefit as this latest economic wave matures.

FROM CONSUMPTION TO EXPERIENCE

While most purchases are still being made in person, community sharing and social networks are creating hundreds of new consumer experience touchpoints that strongly influence sales. For example, 84 percent of car buyers use digital content at some point in their path to purchasing a car. As a result, the average number of showroom visits has dropped from six to 1.6. Nearly half of Millennials prefer social media and the Internet/web chat as their primary contact points with businesses.

In this new environment, brands can no longer rely on consumer loyalty to protect them, no matter the excellence of a service or product. User experience is the key criterion and the source of value creation.

Companies across diverse industries are beginning to realize this and focus on improving the user experience. Examples: passenger airlines and rail operators that offer integrated journey services; delivery logistics firms that customize products and provide up-to-the-minute predictive updates; and hotels that allow customers to select a specific room ahead of time and then use their mobile device as a key.

Success in the new experience economy is all about staying ahead of the curve. This means that touchpoints must be constantly re-evaluated, as the ways in which consumers interact with digital technologies change. Mobile is currently eclipsing desktop, but the Internet of Things and autonomous chat devices (such as

Amazon's Alexa) are edging onto the scene. Keyboards gave way to touchscreens, which are being overtaken by speech and gesture recognition today, and likely virtual reality devices tomorrow. Every such change engenders new demands from consumers in terms of experiences and interactions.

FROM EXPERIENCE TO CUSTOMIZATION

The speed of change in consumer technologies and social media channels makes the purchasing journey a moving target, increasing the importance of personalization – the turning of goods and products into customized experiences. The era of the standardized offer and impersonal website is over: In a recent UK study, nearly 30 percent of consumers said they would stop visiting websites that lacked personalization. And 86 percent of consumers say personalization plays a role in their purchasing decisions.

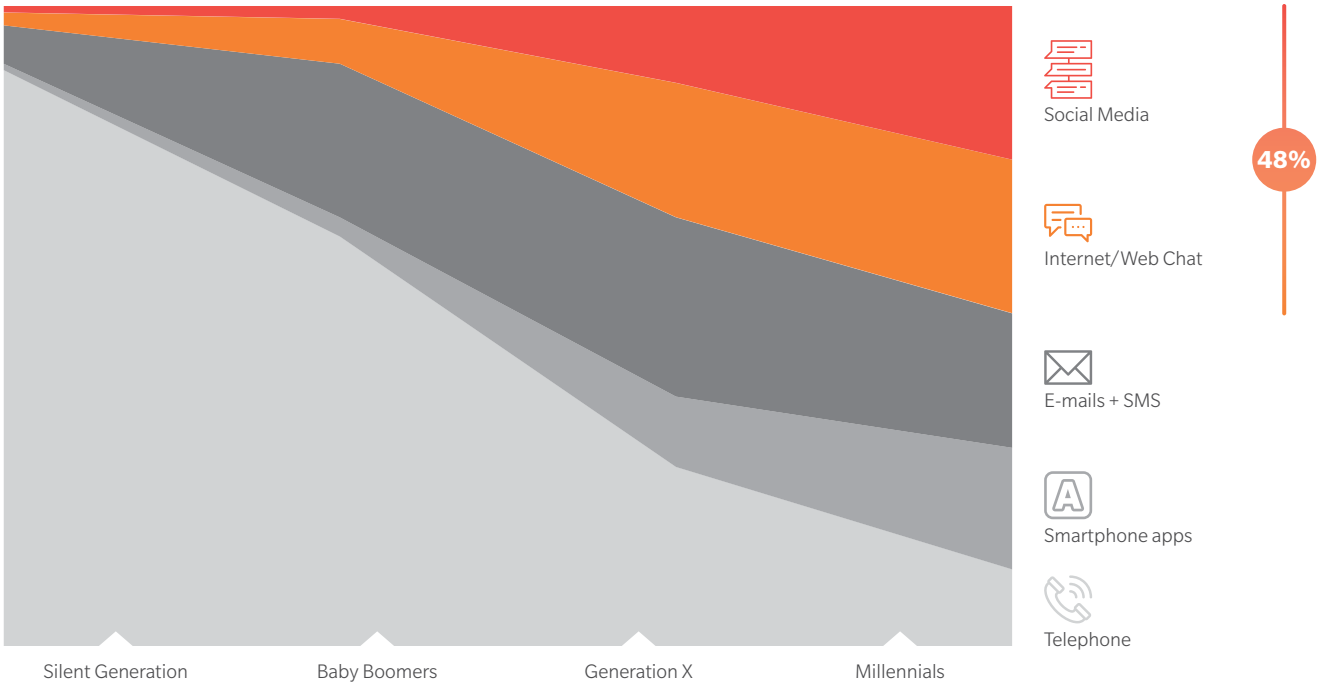
In our estimate, various personalization channels offer the potential to increase revenues by 10-25 percent. In particular, personalization can be a strong lever for companies seeking to regain competitiveness versus market leaders.

As an example, a frequent business traveler searching for a trip to New York might have her search results sorted to prioritize an airline on which she has status, automatically suggesting her preferred aisle seat and offering to book a black car pick-up at the airport and a hotel downtown with several business amenities that is opposite her office.

A different traveler with identical search terms might instead be shown a vacation package with a budget-friendly airline, a family-friendly hotel located in Times Square, and suggestions for a city tour and theater show booking, because he has been identified as a leisure traveler vacationing with his family.

In this environment, design, simplicity, and speed are paramount. Increasing the personalization of customer experience touchpoints has been shown to increase willingness to pay, willingness to switch brands, and willingness to try recommended products by double digits.

MOST POPULAR CHANNELS FOR CONTACTS BY BUSINESSES
PERCENT BY GENERATION, 2015, WORLDWIDE



Note: Silent Generation born prior to 1944, Baby Boomers born 1945-1960, Generation X born 1961-1980, Millennials born after 1981
Source: Statista, Snapchat, Oliver Wyman analysis

FROM CUSTOMIZATION TO THE DATA ECONOMY

In an economy where each client contact point is both an opportunity and a threat, the ability to manage, analyze, and value data has become fundamental to success. But if data is the new oil of the economy, it is largely untapped as yet. It is estimated that nearly all of the world's stored data has been generated in just the past few years, but only about one percent has been analyzed and valued.

Collecting data is no longer the tough part – it's identifying the 20 percent of data that will generate the biggest impact, integrating it across multiple sources into existing business models, and converting it into value. About a third of the value of data is in increasing operational efficiency and supporting real-time analysis and decision making. But we estimate that two-thirds of the value of data today is in how it can be used to enhance customer experiences and increase personalization.

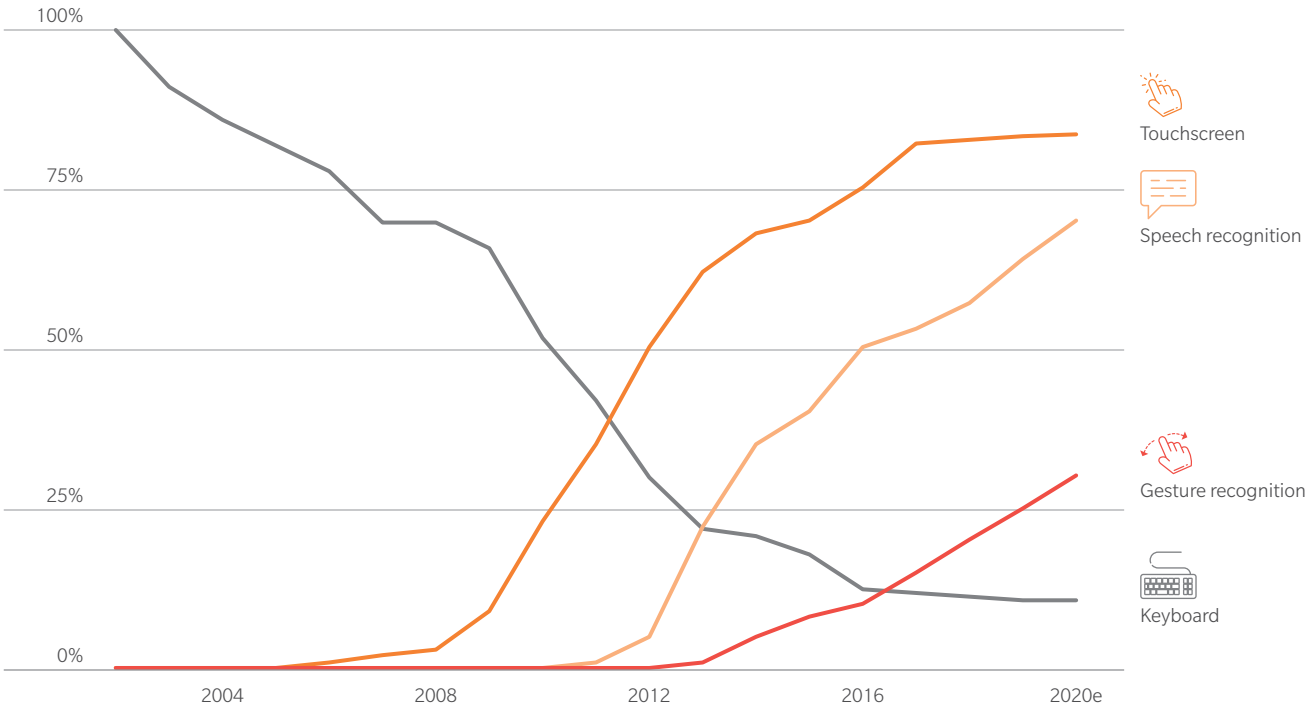
Rather than boiling down the ocean of big data to extract big insights (a time- and resource-consuming process), capitalizing on the emerging data and experience economy will require a "smart data" approach instead: starting with the impacts a company wants to have, determining the actions and insights needed to drive those impacts, and only then extracting and exploiting the data most likely to fuel that process.

There is no room to stand still in today's rapidly shifting, unpredictable technology and consumer landscape. Focusing on experiences, personalization, and smart data are tools that can help all companies keep on dancing even as the music changes.

BRUNO DESPUJOL
Partner
bruno.despujol@oliverwyman.com

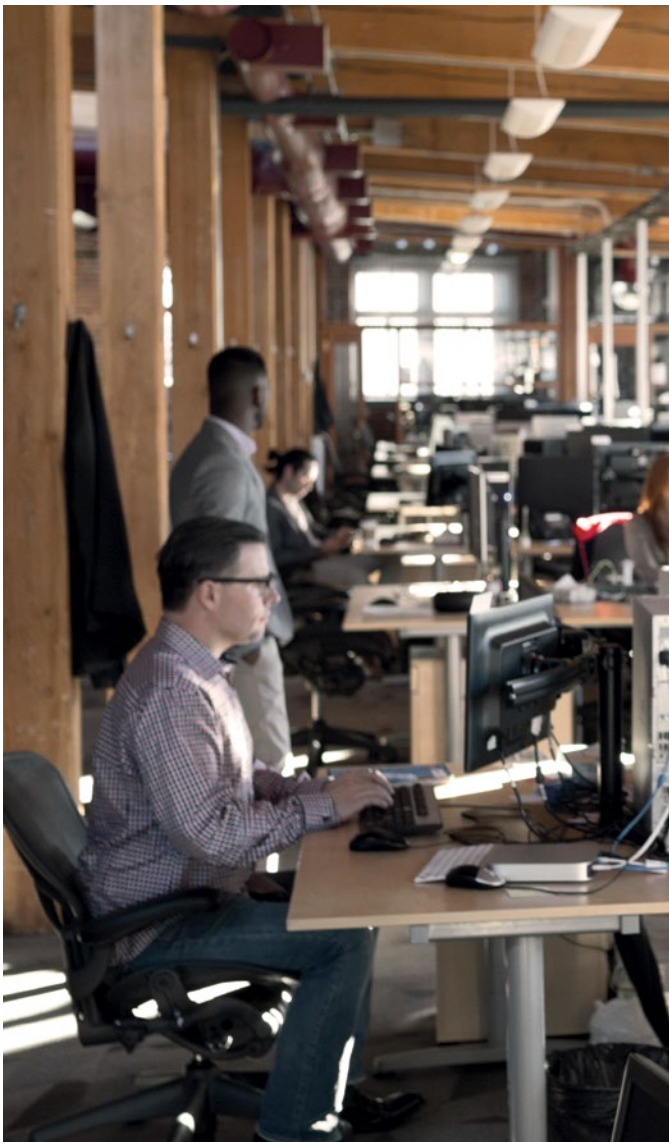
JESSICA MCLAUGHLIN STANSBURY
Partner
jessica.stansbury@oliverwyman.com

PERCENT USAGE OF CONSUMER DEVICE INTERFACES



Note: Includes desktop PCs, tablets, 2-in-1 laptops, and smartphones
Source: Oliver Wyman analysis

HOW START-UPS ARE **DIGITALIZING LOGISTICS**



THE LOGISTICS INDUSTRY is facing digital disruption along its entire value chain – from freight forwarding, brokerage, and long-distance transportation, to warehousing, contract logistics, and last-mile delivery. Agile, innovative start-ups are capitalizing on the high number of transactions and large amounts of data being handled and generated by logistics players to develop an expanding range of technology-driven solutions: Around every fifth day, a new logistics start-up is founded.

Logistics incumbents are being besieged by new digital business models on many different fronts, but could also use these would-be competitors as a springboard to fuel next-generation growth and innovation strategies.

THE RACE TO INVEST

In a recent study, we identified more than 400 start-ups worldwide that could eat into the competitive advantages of logistics incumbents. Five major start-up clusters dominate the landscape: online platforms, asset management solutions, robotics/autonomous vehicles, shipping execution & tracking, and data & analytics solutions. A large percentage of new logistics start-ups are focused on online platforms and data-driven services – areas that are easily scalable and require little fixed-cost investment. But rapid technological evolution means that all identified start-up clusters are seeing a steady stream of new entrants.

While funding is still not at the level of leading business-to-consumer and sharing economy disruptors, logistics start-ups are attracting serious investor interest – more than $11 billion in investments over the past decade. The top ten global logistics start-ups have received around half of this funding. In line with increasing amounts of funding for logistics start-ups, annual funding rounds have quadrupled since 2007.

CHALLENGES FOR INCUMBENTS

Major logistics incumbents have started to carefully invest in digital start-ups. UPS, for example, has developed a Strategic Enterprise Fund to invest in start-ups that complement its footprint – to the tune of some $600 million across 24 investments. DHL has selectively invested in start-ups that promise short- to mid-term leverage, such as Streetscooter, which is developing cost-efficient electric delivery vehicles. And DB Schenker is working with American freight exchange Uship to improve surface transport utilization.

Logistics incumbents are facing intense competition however for the best partners and targets. This competition is coming from outside of the transport and logistics space, and includes a broad range of

heavy hitters: *Technology giants* such as Amazon and Alibaba are investing in start-ups to innovate in last-mile delivery, while others, like Google and SAP, are looking more broadly at advances in big data analytics, artificial intelligence, and machine learning. *Mobility providers* such as BMW and Mercedes are developing passenger and cargo transport platforms as well as autonomous driving solutions. And *venture capitalists* are leveraging their networks and experience in business-to-consumer to quickly scale up asset-light business models in fast-growing areas of logistics.

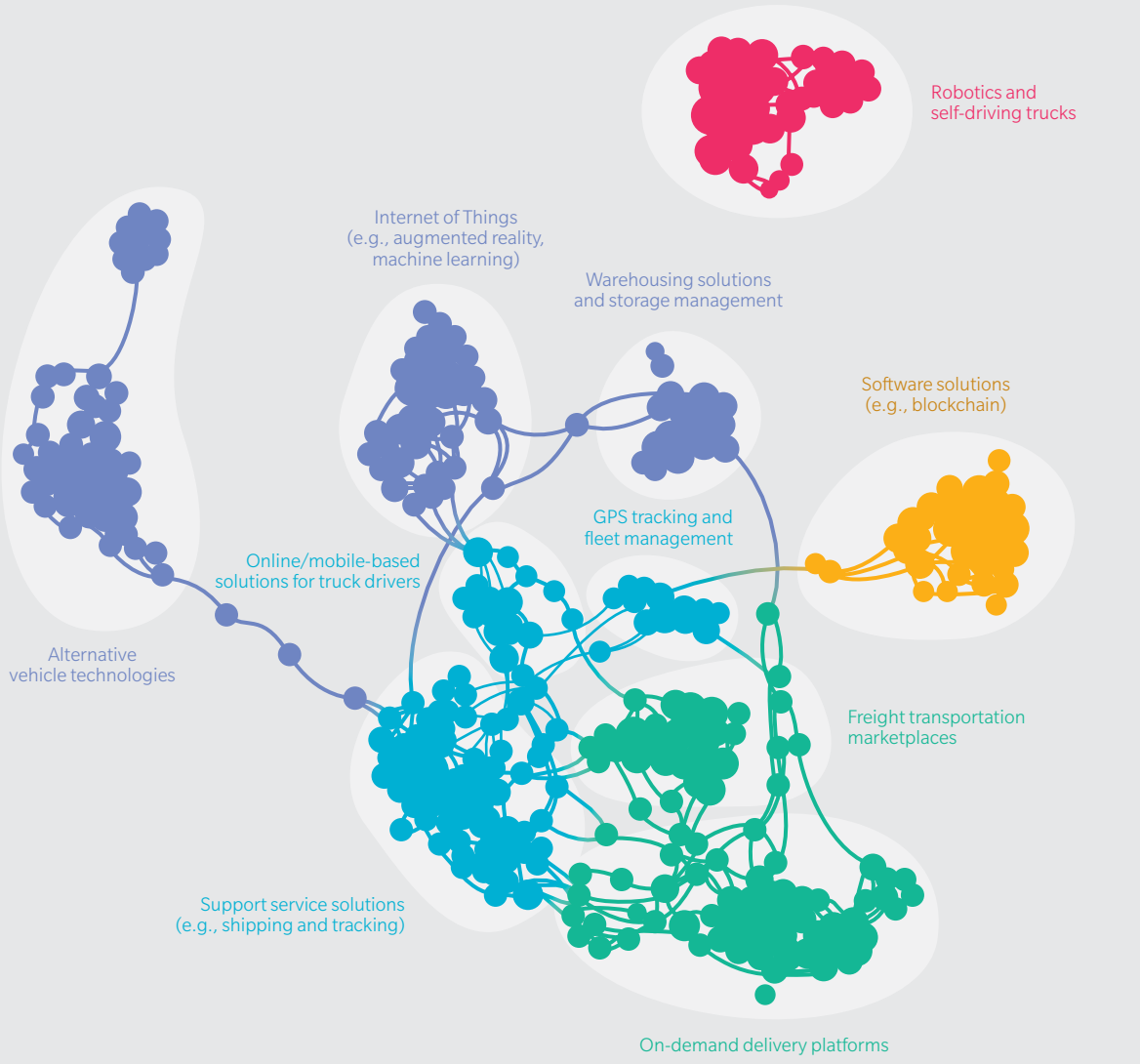
These moves suggest that the key challenge for logistics incumbents may be that they are not integrating and adapting to technological disruption quickly enough to capture competitive opportunities before outside investors do. And start-up investments could be a critical path to leapfrogging the challenges of digitalization for large logistics organizations.

Start-ups can quickly signal which next-gen changes are worth pursuing and which aren't, because they have the flexibility to test and evolve innovative solutions in an agile way. Invested incumbents can then leverage surviving trends to optimize their own operations and improve digital integration with their clients' supply chains and production processes.

COOPERATING WITH START-UPS

Logistics incumbents should not be afraid of disruption through start-ups, but instead need to see them as a means to an end: enhancing and evolving the core

MAJOR LOGISTICS **START-UP CLUSTERS**



Source: Crunchbase, Capital IQ, Quid, Oliver Wyman analysis

business, while establishing ties to the innovation community – entrepreneurs, inventors, and innovators.

A partnership model between incumbent and start-up is vital for investments in start-ups to be effective. Close collaboration can be a means to ensure early development decisions best serve the needs of the business. While efficient control mechanisms are important, they must be developed carefully so as not to interfere with entrepreneurial spirit and innovation culture. And incumbents must complement these external collaborations with internal initiatives to foster their own innovation culture and the acceptance of start-up ideas.

Successful venture capitalists provide another important insight for established logistics companies: traditional profit models need to be rethought. Digital logistics start-ups generally offer scalability in large market segments, together with higher customer lifetime value than the initial acquisition cost. This is a sea change for the conservative and risk-mitigating culture of many logistics incumbents. Tolerating uncertainty and risk, while being flexible with regard to business model pivots, is a virtue that must be shaped actively within traditional organizational structures.

Investing into and partnering with digital start-ups will not, by itself, transform the legacy business of a transport and logistics company. But it can provide access to capabilities and talent to create new digital business pathways. The start-up approach of fragmenting existing supply chains and upgrading the efficiency and transparency of transport businesses through the application of new tools and technologies complements incumbents' legacy capabilities.

Established logistics providers have a window right now to capitalize on the energy and agility of digital startups – or else risk meeting these new entrants head-to-head as competitors in the future.

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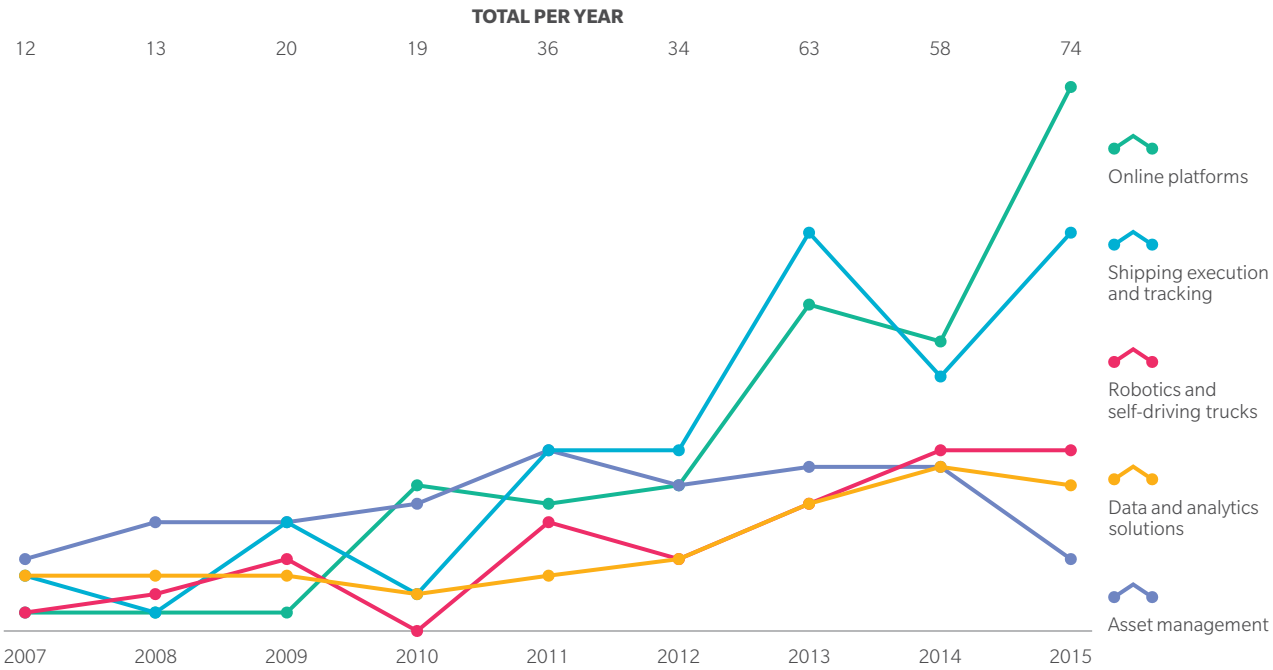
MAX-ALEXANDER BORRECK
Principal
max-alexander.borreck@oliverwyman.com

JORIS D'INCÀ
Partner
joris.dinca@oliverwyman.com

SEBASTIAN SCHAMBACH
Associate
sebastian.schambach@oliverwyman.com

NUMBER OF START-UPS CREATED PER CATEGORY
GLOBAL, 2007-2015



Note: Data filtered by size of investment received, depending on maturity of company (e.g., > $2.5 million for companies older than 2015)
Source: Crunchbase, Capital IQ, Oliver Wyman analysis

THE BLOCKCHAIN REVOLUTION FOR LOYALTY PROGRAMS

LOYALTY PROGRAMS HAVE proliferated across travel, retail, financial services, and other economic sectors. The average US household, for example, participates in some 29 different loyalty programs, according to the biennial 2015 Colloquy Loyalty Census. The result is a maze of point systems and redemption options, together with cumbersome processes for exchanging points among program partners. Loyalty programs are ripe for innovation that would make them easier to use.

Blockchain may be the answer. Best known as the technology behind Bitcoin, blockchain enables a ledger of transactions to be shared across a network of participants. When a new transaction occurs (for example, a loyalty point is issued, redeemed, or exchanged), a unique token is created and assigned to that transaction. Tokens are grouped into blocks (for example, every ten minutes) and distributed across the network, updating every ledger at once. New transaction blocks are validated and linked to older blocks, creating a strong, secure, and verifiable record of all transactions, without the need for intermediaries or centralized databases.

For consumers juggling an array of loyalty programs, blockchain could provide instant redemption and exchange for multiple loyalty point currencies on a single platform. With only one "wallet" for points, consumers would not have to hunt up each program's options, limitations, and redemption rules.

All loyalty programs are vulnerable to a blockchain revolution, but the travel industry is perhaps the most at risk. Travel loyalty programs tend to be complex and multi-currency; program points can even differ by trip component (flight, car rental, hotel, dining), leading to fragmented point collections and some points never being redeemed. It can be difficult for the average

person to even accumulate enough points to earn a meaningful reward.

THE BENEFITS OF DISRUPTION

Industry after industry is experiencing disruption from technologies that reduce inefficiencies and frictions – often disintermediating established players in the process. Large travel companies, such as airlines and hotel chains, know this from experience: They pay billions of dollars in commissions each year to Priceline, Expedia, and other online travel agencies (OTAs) that have transformed how consumers book flights, hotels, and rental cars.

Now, both small startups and large-scale technology companies are looking to innovate around blockchain-based loyalty platforms. Travel companies with loyalty programs, whether standalone or part of a larger alliance, will need to consider when, not if, to adopt blockchain.

Early adopters could benefit considerably. For example, a growing volume of unredeemed points has created a large balance-sheet liability for many industry players. (New accounting standards require that revenue attributable to the value of loyalty points must be deferred until the points are redeemed.) Adopting blockchain would enable companies to rapidly add and maintain loyalty partnerships without adding complexity to their programs. By providing more redemption options, this robust, frictionless partner network would act as a much-needed release valve for these balance-sheet pressures.

Blockchain also would enable businesses to break out of the mold of narrowly defined, one-size-fits-all programs and redemption processes filled with customer hassles. Consumers increasingly expect personalized (not merely segmented) travel offerings and digitally enabled one-stop services – the growth of OTAs is a testament to that. Blockchain would allow both large and local partners to be added seamlessly, making the crafting of on-trend offers much easier, while virtually eliminating the back-end irritations of point redemption.

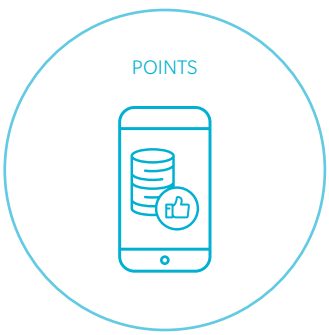
CAVEATS FOR ADOPTION

What shape are blockchain-based loyalty networks likely to take? Initially, each loyalty program might look to develop its own solution, but over time smaller loyalty programs likely would band together to compete more effectively with larger ones. Ultimately, we anticipate the development of four to six blockchain-based loyalty networks, each anchored by a major airline, a major hotel chain, or a group of smaller travel companies. Options for building and maintaining the blockchain platform could include a joint venture with technology partners or with network providers such as banks or payment card processors.

Of course, blockchain platforms that unify multiple loyalty programs could pose some risks. These platforms would add a transaction layer between consumers and program operators and merchants, likely generating a small per-transaction cost – which could grow over time, much like OTA fees. Customer data – a loyalty program's

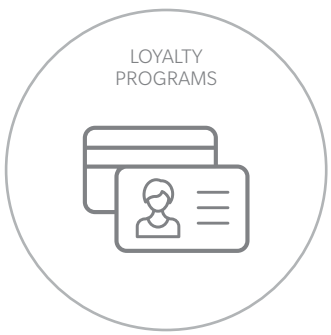
THE CURRENT STATE OF THE LOYALTY INDUSTRY

6.7 TRILLION
POINTS ISSUED EACH YEAR, WORTH $51 BILLION



3.3 BILLION
TOTAL US MEMBERS, GROWING AT 13% PER YEAR

29 PROGRAMS
ON AVERAGE PER EACH US HOUSEHOLD



Source: Colloquy 2015 Loyalty Census

most valuable asset – could become available to other network participants, even competitors. Currency devaluation is another risk in what is essentially an open marketplace for points trading.

Getting in on the ground floor of blockchain platform development would help travel companies reduce these risks. Participating in the initial structuring of commercial agreements and partnerships will be essential to protecting critical loyalty program components, i.e., currency value, customer data and relationships, and transaction costs.

For any travel company considering an investment in blockchain, a few rules will be crucial: First, they will want to participate in defining how currency is exchanged between programs (exchange rates, transferability rules). Second, they should seek to maintain exclusive control over their data, ensuring that only loyalty points enter the transaction stream. And third, they should require guarantees that the platform is and will remain unbiased. Otherwise, traditional travel intermediary tools, such as paid search placements and exclusive promotions, could force companies into pay-to-play arrangements to ensure competitors don't gain an advantage.

In conclusion, travel companies such as airlines and hotel chains recognized too late the power of OTAs to disrupt the industry and have been paying for that misstep ever since. The nascent state of blockchain for loyalty programs, however, offers an opportunity to realize the value of disruption and shape its future impacts – if travel companies don't wait too long.

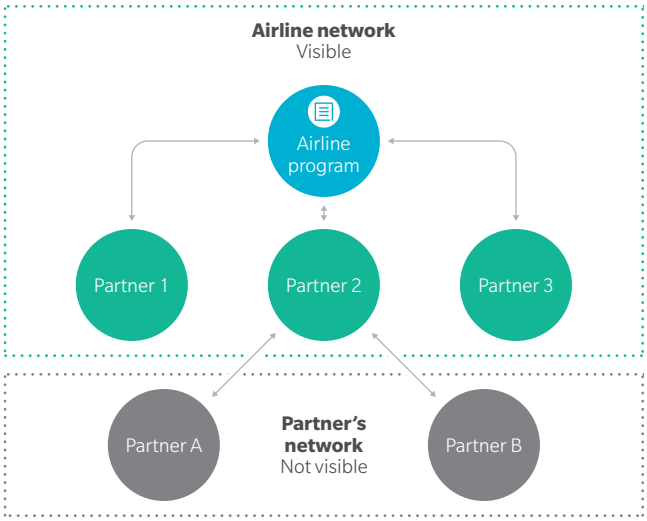
A version of this article first appeared on HBR.org.

JESSICA MCLAUGHLIN STANSBURY
Partner
jessica.stansbury@oliverwyman.com

ALEX HILL
Engagement Manager
alex.hill@oliverwyman.com

HOW BLOCKCHAIN WORKS

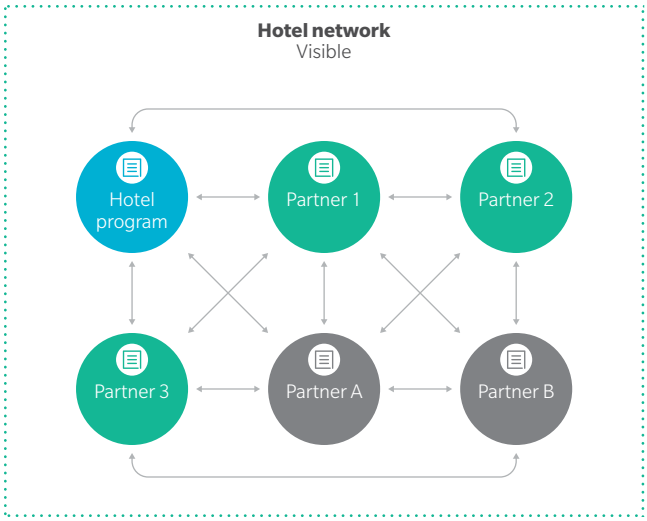
CURRENT STATE: **EXAMPLE AIRLINE PROGRAM**



Maintains ledger of currency balance

- The hotel/airline program maintains the only ledger of record for its currency (points) and connects to each partner independently
- The program has no visibility as to what happens once its currency is converted to a partner's
- Earn/burn transactions and exchanges take days or weeks to post in member accounts

BLOCKCHAIN NETWORK: **EXAMPLE HOTEL PROGRAM**



Maintains ledger of currency balance

- All programs maintain a distributed ledger of all transactions and exchanges, and all partners are connected on the blockchain platform
- All programs can track how currency is earned, burned, and transferred across the network
- Earn/burn transactions and exchanges are posted instantly to accounts

AUTOMATION AND THE CHALLENGE OF **AVIATION CREW FATIGUE**

THE US FEDERAL AVIATION ADMINISTRATION introduced new regulations for aviation crew flight time and duty time in 2013, known as FAR 117. Those changes incorporated the latest in fatigue science, but similar rules have not been adopted worldwide and the science continues to advance, keeping crew fatigue a priority for airlines.

Fatigue is not just about being tired. Tiredness can be remedied by sleep. Fatigue is cumulative, the product of an incomplete recovery from days of insufficient sleep. It affects people who consistently work long hours under stressful conditions. In aviation, its consequences include declining health and productivity of flight crews, rising attrition, and safety concerns.

While regulations need to better reflect the diverse factors that affect fatigue, automation also may hold part of the answer. As aircraft design and flight deck capabilities evolve through technologies such as machine learning, more opportunities are emerging for task automation that could impact crew fatigue – as is happening in other industries with routine or repetitive operations, such as trucking and heavy machinery operation.

INNOVATIONS ON THE HORIZON

For airline pilots, automation could reduce the pressure to manage and monitor parallel and routine tasks in the cockpit, freeing up their mental capacity for more complex computations and judgments. For example, researchers are currently testing resilient machine learning-based autopilot systems that can adapt to changing conditions. These systems "learn" from experienced pilots how to react to situations, rather than having to be explicitly programmed with instructions for every conceivable circumstance.

Ultimately, technology is likely to evolve over time to the point where one crew member is able to handle a sizable chunk of a flight, with automation as the co-pilot – a potential boon given an anticipated pilot shortage in the future. Eventually, a remote pilot on the ground could take the second seat on some flights or flight segments.

Technology is even tackling the fatigue question through the development of devices that can monitor fatigue and adjust the level of automation to ensure sufficient crew engagement. For instance, the trucking industry already uses a system to monitor eye and eyelid movements of drivers to make sure they are alert.

THE RISKS AND REWARDS OF AUTOMATION

While automation could relieve a crew from having to attend to certain routine tasks, it is not a panacea. When it comes to fatigue, automation may also introduce unexpected risks.

Research suggests that reducing or eliminating the stimulation of manual tasks may slow reaction times and bring other fatigue symptoms to the fore. One danger is the phenomenon of microsleeping – moments when part of the brain goes offline, so to speak, while other parts remain wakeful. The phenomenon has been identified as a frequent cause of automobile accidents.

This suggests that the smart way to incorporate automation means first developing a long-term crew fatigue management strategy that recognizes automation's risks as well as its rewards. Robust fatigue management includes developing a detailed assessment of fatigue causes, correlating data on actual duty times

POSSIBLE FUTURE AUTOMATION IN THE COCKPIT

AUTOPILOT WITH ARTIFICIAL INTELLIGENCE

Uses machine learning to learn from experienced pilots, can adapt to changing conditions and crises

AI-BASED WEATHER AND RADAR MONITORING

Continuously assesses weather and radar imagery and makes recommendations to accommodate changing conditions

ELECTRONIC STABILITY AND PROTECTION

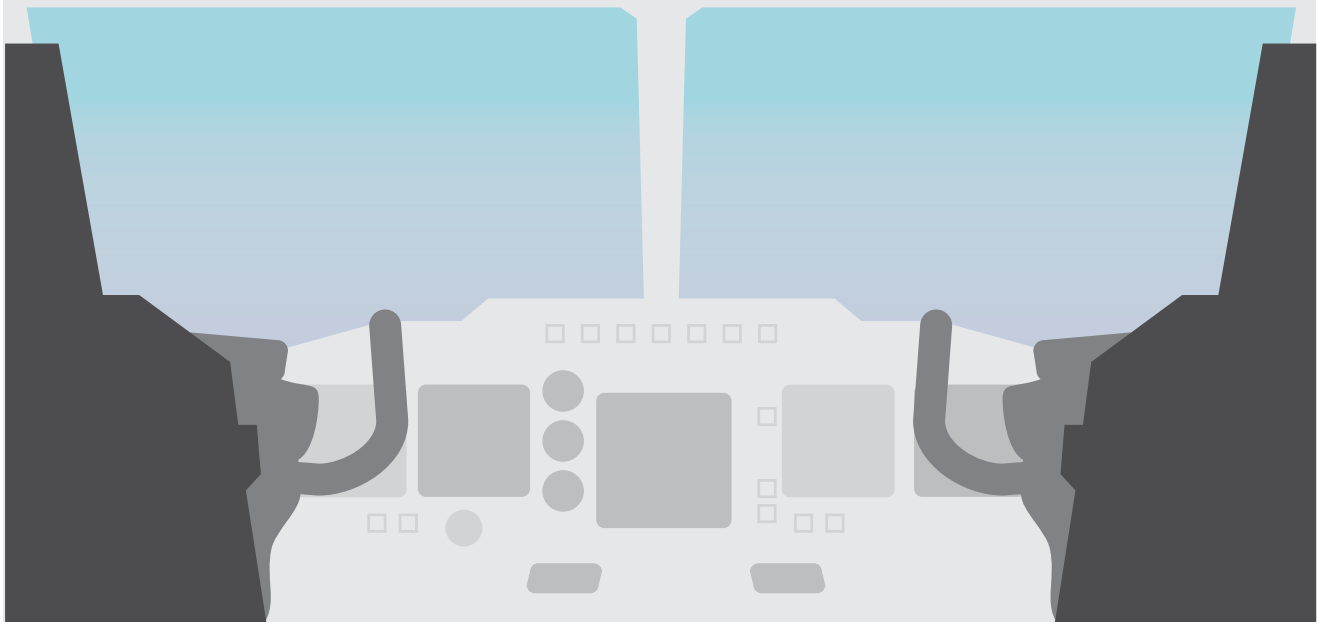
Monitors and maintains the airplane's altitude (even when autopilot is off)

FATIGUE MONITORING AND STIMULUS

Monitors crew fatigue and refines automation level to ensure sufficient engagement

VIRTUAL ASSISTANTS

With speech recognition, able to interact with crew and issue voice commands to complete hundreds of common tasks in the cockpit



and activities with fatigue reporting, gathering crew feedback through interviews, and developing a fatigue risk management system (FRMS) that focuses first and foremost on fatigue prevention.

FINDING THE RIGHT BALANCE

A big part of fatigue prevention is developing realistic and resilient crew schedules that incorporate the latest in fatigue science and accurately reflect a challenging operational environment. In the US, FAR 117 has helped launch that process, but in other cases, regulations have fallen short on addressing the full spectrum of issues that lead to fatigue. While rules exist that govern how many hours crews can work (and how often they can work overtime), regulations vary by geographic market, and limits on flight duty periods do not always take into account more qualitative factors, such as tough routes, cumulative schedule intensity during busy travel seasons like summer, and the impact of standby duty.

Before making decisions on task automation, airlines will need to be able to determine which phases of flight present higher risks for fatigue. And, for days when things don't go as planned, standard protocols need to include sufficient emphasis on crew fatigue and the impact of disruption on crews. As airlines adopt new technology to collect and analyze the reams of technical flight and equipment data now being generated, they have an opportunity to incorporate capabilities into these systems that can gather more information on human factors as well, providing greater insights into fatigue.

No doubt, this is a tricky balancing act for both airlines and regulators. Still, the payoff for good fatigue management coupled with cautious adoption of automation can be substantial: excellent safety records, higher crew productivity, and happier customers.

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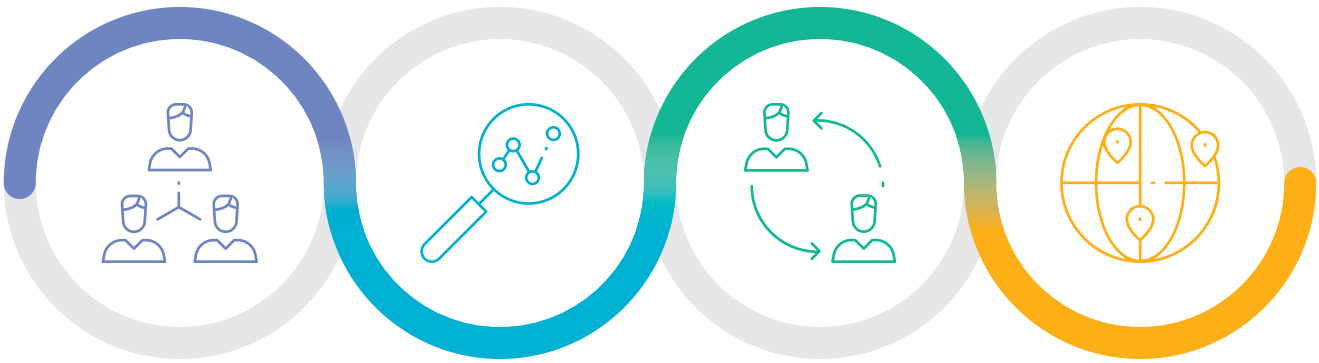
GEOFF MURRAY
Partner
geoff.murray@oliverwyman.com

CHRIS RAWLINGS
Principal
chris.rawlings@oliverwyman.com

MANAGING CREW FATIGUE
A FOUR-STEP APPROACH



ESCALATE

- Raise to the board or an independent safety committee for fatigue monitoring

IDENTIFY

- Establish an enhanced Fatigue Risk Management System (FRMS)
- Promote a culture of reporting and recognize cultural barriers to reporting
- Determine causes of fatigue and distinguish treatments

MITIGATE

- Clarify accountability; build trust and transparency around fatigue management
- Review OTP causes where they impact crew fatigue
- Create a realistic, reliable, and resilient schedule; incorporate fatigue review into end-to-end planning
- Improve ability to manage fatigue in operational recovery

TRACK & SUPPORT

- Invest in systems, tools, and training
- Embed reporting and agree thresholds or flags for action
- Provide technology and processes to support fatigue management

META-PLATFORMS AND THE EVOLUTION OF DELIVERY LOGISTICS

CONSUMERS TODAY ARE MOTIVATED by convenience when it comes to purchases of products or services – getting what they want, when and where they want it. Couple this with the digitalization of the supply chain and the prospects for artificial intelligence, and a vision of the future of delivery logistics begins to take shape.

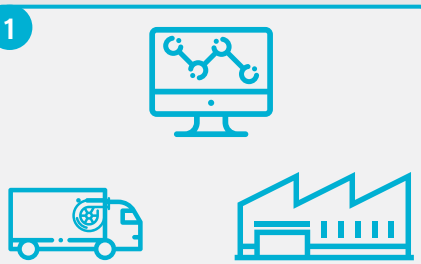
This future will be more asset-light and agile, compared to the asset-intensive operations of today's major logistics companies, with their fleets of trucks and planes. Making market entry easier for hungry tech disruptors, the focus of delivery logistics is increasingly shifting toward customer data, connectivity, and operational flexibility.

A key enabler of these changes will be the development of "meta-platforms" – massively wide, deep, and intelligent computing environments that allow logistics companies to interact with disparate and rapidly changing operating systems, software, and apps – and, most importantly, across company boundaries to seamlessly service their customers. These meta-platforms are not likely to be directly end-customer facing; instead, they will steer the logistics flow of products on the operations side, while ensuring that operations is well connected to sales – where customer preference data resides.

Meta-platforms are thus at the heart of future delivery logistics systems, and even today's early adopter meta-platforms – such as Amazon's – have proven to be a road to industry dominance. (Amazon's meta-platform provides customers with transparency into order status and integrates downstream delivery partners, but as yet does not enable customers to change where and when

META-PLATFORMS IN ACTION: AIRLINE PART REPLACEMENT EXAMPLE

1



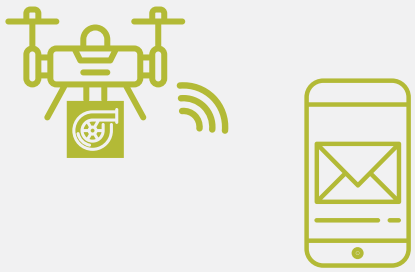
An OEM's forecasting system predicts that an airline will have a thrust reverser failure (probability 60 percent). The breakdown location is predicted to be either Denver or Chicago in 18 to 22 days. A thrust reverser is ordered from the distributor and shipped to a centrally located delivery logistics provider. The OEM informs the airline of the likely breakdown and predictive shipping.

2

A breakdown of a thrust reverser occurs on one of the airline's large aircraft. An on-board computer detects the problem in flight and transmits the requirement for a new part to the OEM and the airline's maintenance hub. The information is assessed and approved, triggering delay-saving actions.

3

The new part is labeled and sent via drone for same-day delivery as soon as the electronic order comes in. The airline's flight operations center is informed of the expected repair time, a replacement plane is requested, and airports and passengers are digitally informed of expected flight delays.



4

A technician is notified that the plane will be landing and of the part replacement that needs to take place. She is given an estimated time for the arrival of the part and views a detailed repair demonstration via a virtual reality system.

5

The part arrives via expedited drone service. Using a detailed repair plan sent by app, the technician replaces the broken reverse thruster. All data on the breakdown is saved in a centralized database to further increase prediction accuracy.

shipments will be delivered, nor does it fully integrate upstream and downstream transportation options.)

Through the use of meta-platforms, networks that were once established to simply push goods through at the lowest possible cost will be able to evolve to offer customized solutions that reflect customer priorities. Thus, for example, it will soon be possible to have a spare part from one place and a mechanic from another standing at the ready to service a plane landing at a third location, without disrupting the airline's schedule, all initiated by an automatic alert from the plane. Or, an overnight shipment headed to one factory will be rerouted while en route, based on a sudden need at another factory, and still arrive on time.

DRIVEN BY DATA

As meta-platforms evolve to incorporate more big data analytics and machine learning, layers upon layers of customer data will drive their competitive value. Goods will be routable depending not just on the geography of the destination, but numerous other factors: For example, is this a VIP customer? Was it a discount sale? Are there other purchases that should be bundled together? Some of this happens now, but it takes considerable human intervention, which slows down the process and carries a higher risk of errors. In the future, deliveries will be channeled automatically by technology that can make decisions efficiently and quickly.

Sales platforms will no longer be able to offer just a few generic options and hope they cover a customer's situation, once meta-platforms are able to reach out to customers and report back their delivery needs and expectations in real time. For example, if a buyer doesn't need same-day delivery, then offering it isn't worthwhile. Instead, the customer might want to be able to change the destination of the package at any time, and the ability to deliver on that promise may determine which company gets the business.

This emphasis on data and customer knowledge is why an enterprise such as Amazon has been able to outflank more established logistics companies. Like many other technology-based disruptors, Amazon focuses on getting to know as much about each customer as possible. This is true for Google as well, and the reason both of these companies have been able to integrate themselves so easily into the supply chains of many different industries.

This transition has taken away the advantage traditional logistics suppliers once had and has attracted a raft of new asset-light digital natives to the space. (See "How Start-Ups Are Digitalizing Logistics" in this issue.) Even Amazon, which has always been involved in logistics, continues to create smaller, more nimble operations, such as Amazon Fresh and Amazon One, to perfect logistics for various industries. Traditional logistics suppliers will find it challenging to follow suit unless they develop the same levels of connectivity and data analytics.

NEXT-GEN LOGISTICS

With meta-platforms as an enabler, the future of delivery logistics will involve diverse solutions accommodating diverse needs. Some of this future is already being beta-tested, such as locker stations with roofs that accommodate drone delivery of packages (a conveyor belt takes packages the final few feet to customers' lockers), or apps that allow customers to re-route packages mid-delivery. In some European and US cities, remote-controlled delivery carts now share the sidewalk with humans.

Advances in data science will be required, however, to make this future fully a reality. Just having terabytes upon terabytes of data isn't enough, if it's sitting in 20 different databases scattered across the supply chain. And delivery systems with high levels of volume fluctuation will need five critical enablers: connected data along the entire value chain, dynamic planning, agile networks, enhanced channel management, and open platforms integrating all channels with customer interfaces.

Equally key will be the further development of nascent technologies. For example, 3D printing will allow the production of spare parts and products closer to the customer and faster customization. Augmented (virtual) reality could help reduce returns by enabling customers to make better choices when they order, thanks to three-dimensional modeling and interactivity.

Ultimately, due in large part to the connectivity enabled by meta-platforms, most of us won't even recognize delivery logistics a decade from now: Fleets of drones buzzing by as they deliver and pick up packages, mobile lockers driving autonomously through cities, and robots cruising down neighborhood sidewalks on quick trips from local stores. Incorporating all of these new ways of operating may require companies to seek out partners or even crowdsource solutions, but simply standing still will no longer be an option.

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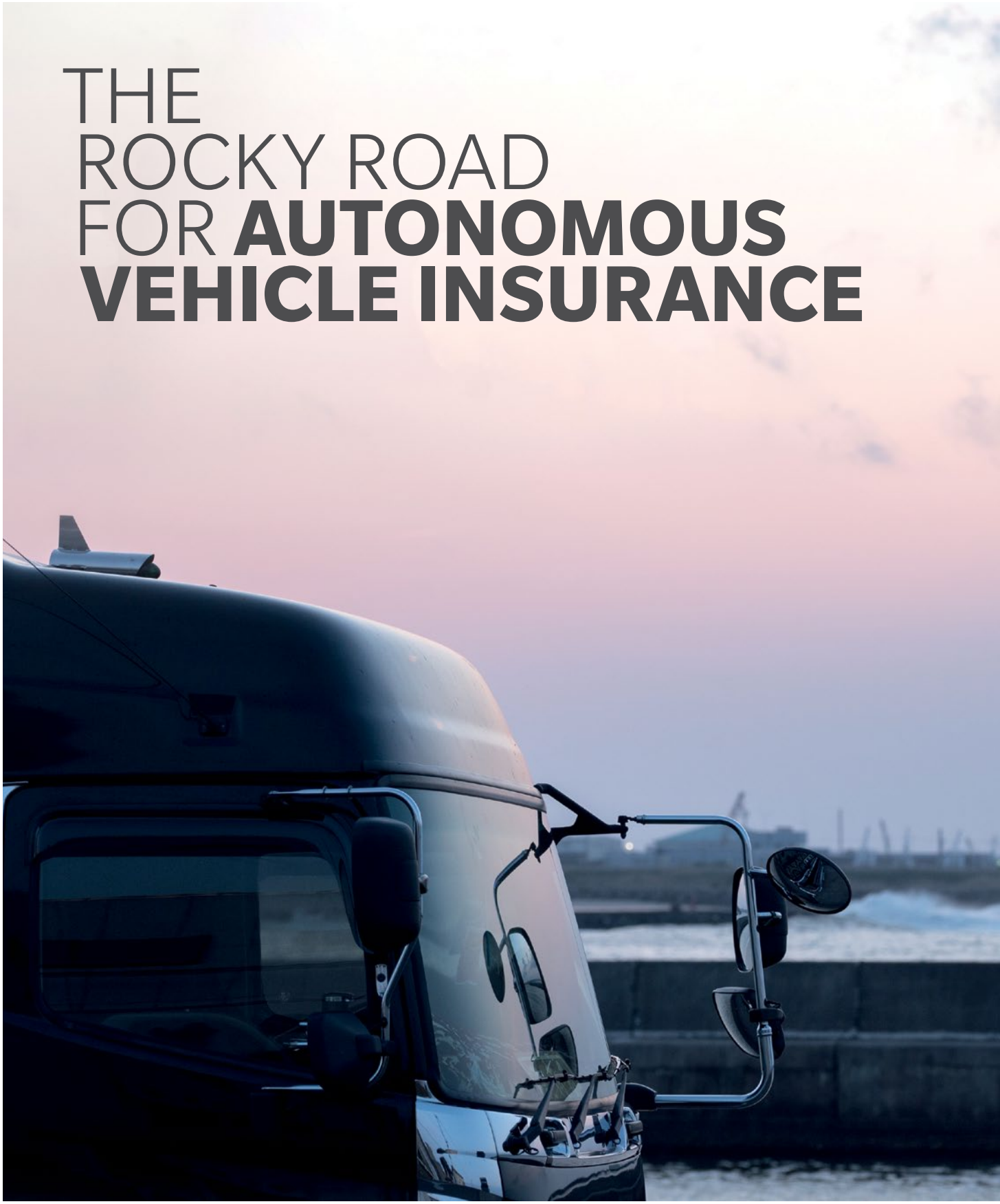
CORNELIUS HERZOG
Engagement Manager
cornelius.herzog@oliverwyman.com

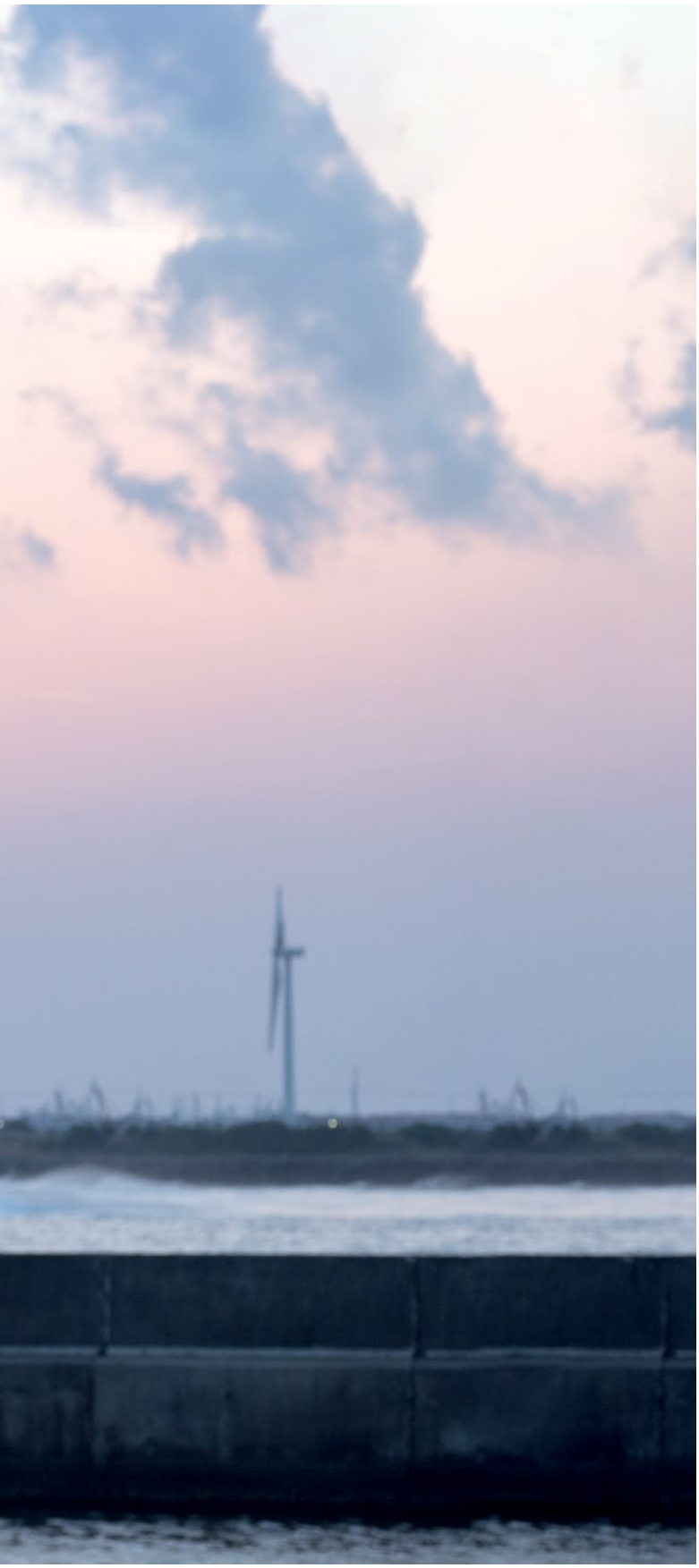
DR. MICHAEL LIEROW
Partner
michael.lierow@oliverwyman.com

STEFFEN RILLING
Senior Consultant
steffen.rilling@oliverwyman.com

Operations

THE ROCKY ROAD FOR **AUTONOMOUS VEHICLE INSURANCE**





WHILE FULLY DRIVERLESS cars and trucks as a regular feature on the roads may still be some years away, vehicles with some level of autonomous capabilities or artificial intelligence – what are known as advanced driver assistance systems – could jump from a little more than 10 percent in 2015 to close to 40 percent of all vehicles by 2025.

One of the more critical issues to be resolved is how insurance will change as vehicles get smarter. Advanced driver assistance systems will upend accidents and claims experience. Without historical data to go on, insurers will need to develop more flexible processes and analytical capabilities to accommodate rapid technology evolution.

As part of this process, it will be important for transport fleet operators and vehicle manufacturers to work with insurers to provide a steady stream of data as a basis for new pricing and underwriting models.

THE OUTLOOK FOR ACCIDENTS AND PREMIUMS

Autonomous vehicles offer the prospect of eventually eliminating most traffic accidents caused by human error: insurance giant Swiss Re projects that advanced driver assistance could cut up to 45 percent of accidents by 2020.

That improvement won't happen overnight, though, and autonomous capabilities might even contribute to some accidents near term, as the bugs are worked out of these systems. Nearly all driverless test cars in operation today have been involved in crashes, mainly because they didn't anticipate that humans don't always respond logically when driving or follow the rules of the road. Human drivers, on the other hand, don't always accurately gauge what to expect from autonomous vehicles. Most likely, accident rates will decline gradually over time, as machine learning makes for smarter vehicles and human drivers get used to how autonomous vehicles interact.

There are predictions that premiums could decline by as much as 60 percent once self-driving vehicles become plentiful and vehicle losses and damage begin

to fall. Before that point, however, there is potential for significant volatility. The insurance industry has been built on being able to look backwards to assess risk, but now will have to get used to more agile and experimental processes, making pricing more of a moving target.

THE NEED FOR NEW DATA AND ANALYTICS

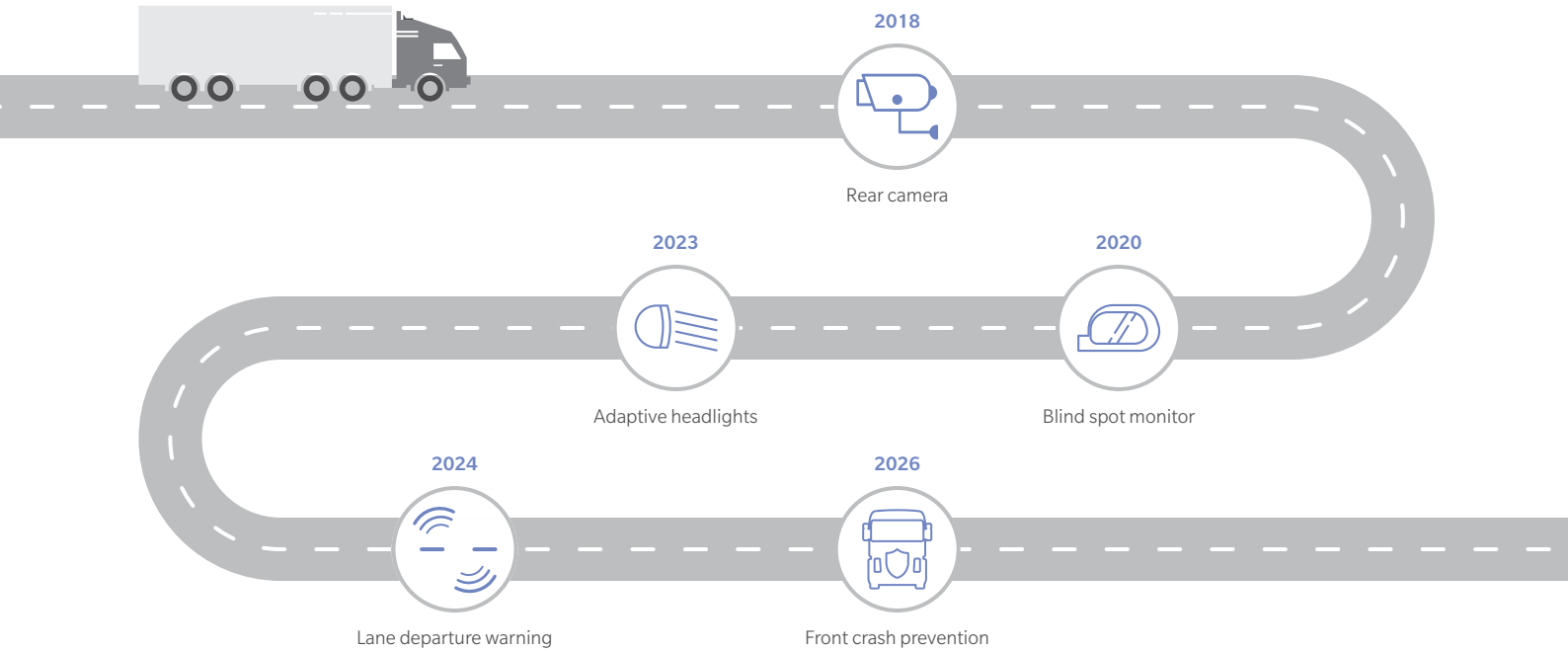
A pivotal necessity for insurers will be developing the ability to analyze and act on real-time data. Insurers will have to become vacuum cleaners for relevant statistics and develop rapid-fire analytics to decipher them. For example, what will it mean from an insurance pricing perspective when half of the cars and trucks on the road have lane departure warning systems and another third have automatic braking? This is further complicated by the fact that systems are being produced by different manufacturers, with some more effective than others.

Data is a higher priority for the industry than ever. Since the 1990s, vehicle insurers have been seeking more granularity in their risk assessments and market segmentation, increasingly asking more questions of potential policyholders. In Germany, for instance, insurers had five risk criteria in the mid-1990s, but now have as many as 50. Because each insurer has its own criteria and algorithms, many pricing models are now black-box calculations and not easy to back-calculate from the outside.

To collect more detailed data, major insurance carriers – for example Geico and Progressive in the US – are offering some customers an option that lets them pay as they drive, monitoring either how well they drive or how much via a telematics device. Telematics may be a way forward for insurers to tackle one of the biggest obstacles they confront – developing the IT capability, either internally or through outside service providers, to cope with frequent, real-time, and unstructured data.

The same is true for car and truck makers, when it comes to both data collection and IT upgrades. Like insurers, they will need to constantly refine their products based on feedback from the road. Manufacturers such as Tesla already swear by data collection, which in Tesla's case goes far beyond the typical telematics system. The electric car maker literally upgrades its models through software downloads and considers itself as much a technology company as a car maker.

YEAR WHEN 40 PERCENT OF THE FLEET WILL HAVE A SPECIFIC ADVANCED DRIVER ASSISTANCE TECHNOLOGY



Source: Highway Loss Data Institute, Oliver Wyman analysis

REDEFINING RISK AND INCREASING COLLABORATION

This new real-time data will be crucial in determining fault in an age of autonomous control. With the transition to self-driving vehicles, the insurance industry is already envisioning gradually moving from individual coverage to insuring vehicle and software manufacturer risk.

Even if some manufacturers of self-driving features accept responsibility at the front end for malfunctions of their systems, however, as Volvo in 2015 committed to doing, this does not necessarily eliminate the risk once plaintiff lawyers get involved. The newness of the situation is likely to lead to an increase in litigation, especially given the complication of assigning blame when technology is a factor.

In these early years of autonomous capability development, collaboration will be key for vehicle manufacturers, transport fleet operators, and insurers. Establishing ties early in the game will be useful for developing and sharing the data and analytics they will all need to understand how the technology will impact their respective industries and the relationships among them. These various industries also may find it useful to cooperate in terms of providing input to regulators, as governments begin to reshape the claims process and redefine the concept of fault to reflect the new landscape. And it will be in the best interests of operators, manufacturers, and insurers to make sure that insurance solutions continue to be cost effective and efficient as autonomous vehicle technology evolves.

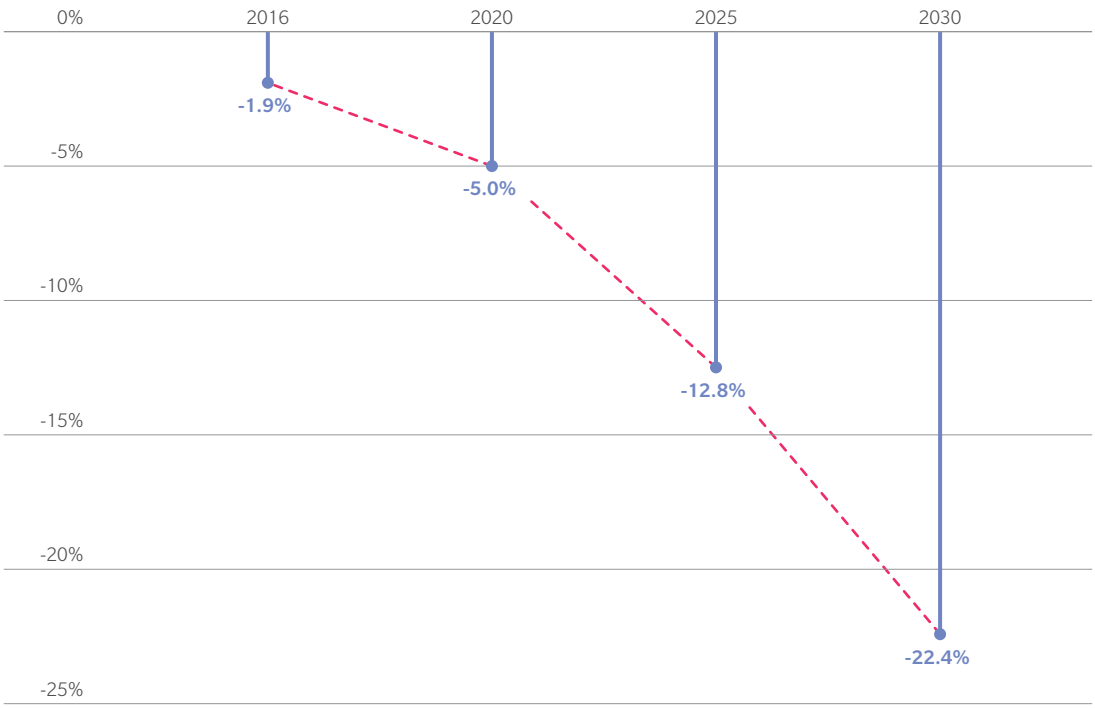
A version of this article first appeared on Forbes.com.

MARC BOILARD
Partner
marc.boilard@oliverwyman.com

FADY KHAYATT
Partner
fady.khayatt@oliverwyman.com

ROUGET PLETZIGER
Principal
rouget.pletziger@oliverwyman.com

PROJECTED REDUCTION IN LOSSES FROM ACCIDENTS AS AUTONOMOUS CONTROL FUNCTIONS INCREASE IN CARS AND TRUCKS



Source: Oliver Wyman analysis

DISRUPTION: THE FUTURE OF **RAIL FREIGHT**

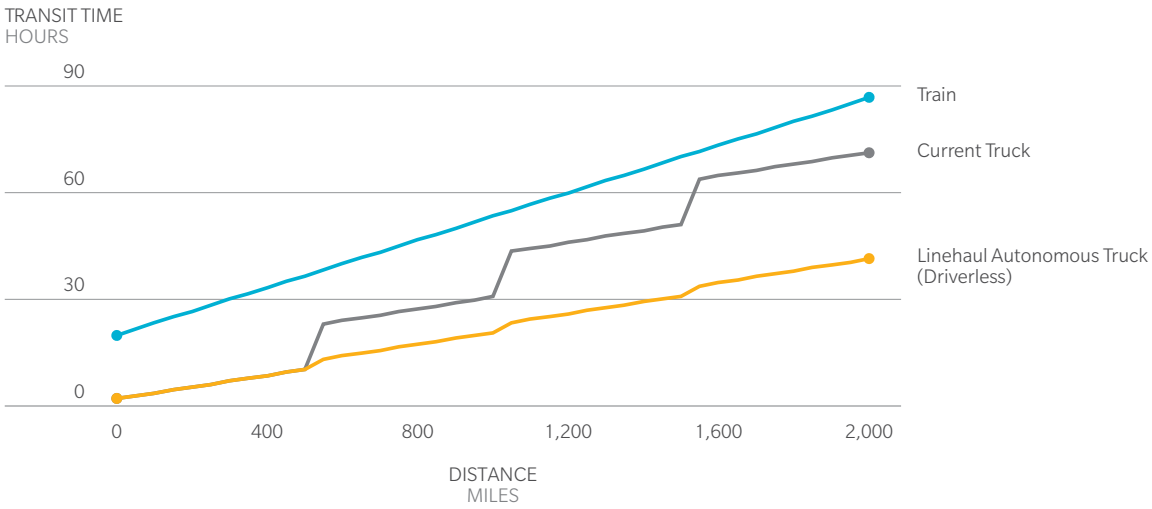
MANY INDUSTRIES ARE experiencing technological disruption from outside forces. Rail freight is no exception, as advances in trucking technology may soon put pressure on the industry. Some believe that "supertrucks" and electric/autonomous vehicle technology could lower trucking's cost of doing business substantially within a decade. Coupled with door-to-door service, quicker delivery times, and better on-time performance, trucking could challenge a large share of railroad markets.

To address this threat, railroads will need to make quantum leaps in both technology and operations. Simply keeping up with trucking technology changes won't be enough: Railroads must look to be resilient, market-responsive, and future oriented. In our view, there are five critical areas where railroads could "disrupt from the inside" to help drive innovation and growth.

#1 AUTOMATING FASTER

The specter of driverless trucks is getting closer every day. Platooning, in which one driver controls several following trucks, is being tested in multiple locations and may soon be a commercial reality. But driverless trains are equally possible; in the US and Europe, railroads are halfway there, thanks to positive train control systems (PTC), which allow trains to be

AUTONOMOUS TRUCKS: GOING FARTHER AND FASTER
TRANSIT TIME VERSUS DISTANCE



Source: Oliver Wyman analysis

monitored and stopped remotely, and trip optimizer systems (a form "cruise control"), which optimize fuel consumption.

Mining giant Rio Tinto is currently testing autonomous trains in Western Australia, which suggests that arduous and remote routes might be ideal for initial deployment. Even if regulation or labor contracts aren't there yet, railroads can start getting ready for more automation. For example, track and rolling stock inspection could be automated by equipping locomotives with smart track sensing technology, while detectors on railcars could monitor wheels, bearings, and brakes for problems. Through machine learning, train dispatching could leap the final hurdle into monitoring trains without human intervention.

#2 IMPROVING FUEL EFFICIENCY

Currently, commercial diesel trucks get seven or eight miles per gallon. The US Department of Energy's SuperTruck program has pushed that to 12-13 miles per gallon – making such trucks cost effective at longer distances. The next phase, SuperTruck II, is now underway, with the goal of doubling baseline fuel efficiency.

The trucking industry also has been willing to experiment with alternative fuel options. For example, United Parcel Service has 4,000 liquid natural gas (LNG) and compressed natural gas (CNG) trucks in the US, while some 550 LNG/CNG fueling stations have been built around the country. Tesla and Mercedes are building all-electric trucks, and Nikola Motor, Toyota, and Peterbilt are incorporating hydrogen fuel cells into hybrid trucks.

Some fuel-efficient rail technology has moved forward in Europe; less so in the United States. But future generations of locomotives will have to be more fuel efficient as trucking fuel costs drop. Feasible options might include hybrid locomotives that can capture regenerative braking energy, locomotive electrification, and hybrid fuel cells (see sidebar: "What's Next for Locomotive Technology?"). New technologies could be tried first in low-risk, local environments with a view to scaling up the most promising ones.

#3 REPLACING ASSETS FASTER

The life cycle of the average commercial truck is only 3-4 years. This means less maintenance overall and the ability to realize technology innovation benefits quickly. For example, the maintenance costs of new hybrid fuel cell/electric trucks unveiled last year are almost nil.

By comparison, locomotives are engineered to last 30 years and railcars 50, meaning they need increasing maintenance as they age. And while they last a long time, they don't get any better. This is why we replace our cell phones every 2 years, our computers every 3 or 4, our cars every 5 or 6 – because today's rapid technology cycles improve efficiency and add features. Perhaps locomotives and railcars only need to be designed for 10-15 year lifespans, to take advantage of the breakthroughs that could cut both operational and maintenance costs.

#4 MAKING BETTER USE OF ASSETS

Both business-to-consumer and business-to-business companies are being forced to restructure their supply chains: smaller shipments, more frequent service, higher reliability. What this means for the rail industry is that many trains are now too large. They spend a lot of time waiting around to be filled, and rail assets – from cars and locomotives to train crews and yard space – potentially could be used more efficiently. More frequent and smaller trains would be more responsive to today's supply chain needs – while also maximizing the use of assets.

In the future, predictive analytics and machine learning ("smart railcars") could offer yet more options to improve asset usage – but ongoing research and testing will be necessary to find out.

#5 CLAIMING MORE OF THE SUPPLY CHAIN

Large railroads are used to doing one thing well – moving large amounts of goods over long distances. Their presence in other links in the supply chain is often limited. Instead, intermodal marketing companies (IMCs) manage lucrative intermodal goods shipments, while other private operators manage first- and last- mile services (shortlines, auto ramps, intermodal and transloading terminals).

It might be time for railroads to get out of their operational comfort zone. There's no reason a railroad couldn't expand its ownership of ramps and terminals or broaden its use of joint rail-truck operations. Railroads already possess the necessary freight management skills and supporting information technology, so growing along the supply chain might be the ultimate competitive edge.

PUTTING IT ALL TOGETHER

Railroads have all of the building blocks to take advantage of changing technology and market imperatives. The critical issue is less one of playing catch up than determining how to assemble those pieces into a pattern that fits with the new digital economy. In short, by embracing reinvention and risk, the railroad industry can realize the vast potential that disruption has to offer.

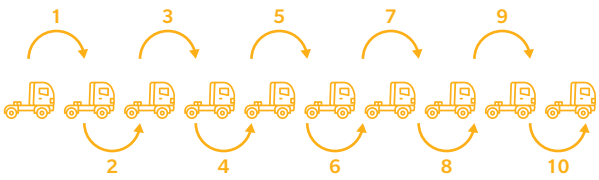
RODNEY CASE
Partner
rod.case@oliverwyman.com

JASON KUEHN
Vice President
jason.kuehn@oliverwyman.com

BILL RENNICKE
Partner
bill.rennicke@oliverwyman.com

Jarod Hage, a Specialist in Oliver Wyman's Transport & Services Practice, contributed to this article.

TRUCKING VERSUS RAIL
PACE OF TECHNOLOGY ADOPTION



TRUCKING INDUSTRY TECHNOLOGY CYCLES

- Average fleet age 1.5-1.7 years (some large companies)
- Allows fleet to be quickly sized to business levels
- Tractors operate half of their warranty life
  - High resale value
  - Low maintenance cost
- Quick implementation of new technologies to lower fuel consumption, utilize alternative fuels

CLASS I RAILROAD INDUSTRY TECHNOLOGY CYCLES

- Average fleet age ~18.4 years
- Long-lived assets, cannot size fleet to business levels easily
- Minimal secondary market
- Slow adoption of new technology
- Currently reducing costs by running larger trains and locomotives

WHAT'S NEXT FOR **LOCOMOTIVE TECHNOLOGY?**

MOST FREIGHT MOVING by rail is pulled by *diesel-electric locomotives*. But that technology is pushing up against the limits of what it can achieve while still improving fuel efficiency and reducing operational costs. In the US, for example, that "virtuous cycle" recently broke down entirely, when new government mandated emissions cuts actually increased the amount of fuel locomotives must burn. As truck technology improves, railroads will need to look elsewhere for innovations to stay competitive.

Liquid natural gas (LNG) has been tested by railroads since the 1980s. It offers lower fuel prices and emissions but has made little headway, given the cost of LNG fueling infrastructure, the difficulty of using dual fuel systems, and the decline in diesel fuel prices. One regional railway in the US, the Florida East Coast Railway, has completely converted to LNG, but it has only 360 miles of track, rather than the tens of thousands of miles of major US railroads. The railroads may need to look more carefully at how trucking is innovating with LNG, i.e., start in the terminal areas first and then scale up promising technology on main lines, rather than converting main lines on the first try.

Hybrid locomotives run on diesel fuel but have on-board batteries to help improve fuel efficiency. For example, DB Cargo AG is partnering with Toshiba to convert 300 older locomotives to hybrids. Most hybrid locomotives also employ regenerative braking, to capture and store the kinetic energy from slowing down in the batteries. This alone can reduce fuel consumption and emissions by up to ten percent.

A fast hybridization option could be to add battery tenders (specialized cars) behind existing locomotives, enabling fast swapping and off-train recharging. This could drastically lower fuel needs and maximize regenerative braking potential. These battery boxes on wheels could then be recharged at solar, wind, or natural gas stations.

Electrification, while not much used for freight in the US, is common in Europe. It can reduce energy and maintenance costs, and generates zero emissions from the locomotive (and zero overall if renewable energy is used to generate the electricity). The International Union of Railways estimates electricity costs are only 50-60 percent of diesel.

The biggest stumbling block to date has been the cost of catenary (overhead wire) infrastructure, but that might be changing: New super-capacitors could make up to 95 percent of trackside electrical systems unnecessary, by enabling on-board energy storage between recharging stations. Electrification of high-speed and high-capacity main lines could become much more realistic from a cost perspective.

A broken "virtuous cycle" means that railroads will need to innovate to reduce fuel costs in the future

Finally, *hydrogen fuel cells* provide continuous power, supplemented by a battery for peak power. Hydrogen fuel cells are attractive as they produce zero emissions other than water and are more energy efficient than combustion engines. Plus, liquid hydrogen can be created using renewable energy sources. There are still issues to work out, however, including increasing hydrogen storage capacity and travel range, and the need for hydrogen fueling infrastructure.

As this brief survey shows, railroads do have technology improvement options. Partnering with relevant innovators could be one route to determining if old technology ideas might now be more viable or if technology ideas from other industries could be adapted. But the changes needed in the future will be more than the merely mechanical: they also will require fostering an innovation culture and the willingness to break down barriers to change.

MACHINE LEARNING: A TURNING POINT FOR PREDICTIVE MAINTENANCE?

OVER THE PAST decade, a radical increase in computational power, data storage, and ever-larger volumes of data have reshaped the competitive landscape of diverse industries. The ability to extract meaningful information from large volumes of noisy, disparate data at an industrial scale and integrate such findings into business can offer organizations many benefits. Predictive maintenance is one such critical space, especially for the rail and aviation industries.

Predictive maintenance involves using time-based data from in-service assets such as trains and planes to predict maintenance needs in advance. A key objective of this approach is the ability to correctly predict the right moment to repair or replace a part. If done too far in advance, the benefits of longer usage are lost; if done too late, unexpected failures can result, reducing asset availability. Thus, improving the accuracy of component lifetime predictions is an ongoing goal.

Cutting-edge tools for delivering such predictions include machine learning-based methods. Machine learning is a form of artificial intelligence, in which computers learn to detect complex patterns by analyzing large data sets. Although the basic framework and principles were developed decades ago, the data volumes and computing power that could make machine learning a reality did not exist until recently.

GETTING MORE FROM DATA

Machine learning is becoming a driving force in the field of industry-grade predictions, delivering significantly more reliable forecasts than traditional statistical

methods, particularly where there is access to vast quantities of "unstructured" data (i.e., data that is not organized in a predefined manner). And as digitalization transforms end-to-end business models, the application of advanced analytical methods like machine learning are no longer just "good to have" – they will soon be business critical.

For more than a decade, rail and aerospace have been using "preventative" maintenance, which involves simpler analytical solutions that don't endeavor to predict failures – instead erring on the side of caution by replacing parts systematically, often using equipment sensor data as a baseline indicator of system health. Predictive machine learning models, on the other hand, can make use of information embedded in previously untapped data sources and account for complex underlying relationships. As a result, these models can help identify failure patterns in components that would otherwise be difficult to detect.

As an example, we partnered with a North American railroad to use machine learning to predict the reliability of specific railcar components. Within weeks, the team was able to train a model that could predict certain component failures up to 40 days in advance, with an accuracy of up to 78 percent. Further, machine learning tools could potentially capture some of the niche technical and empirical knowledge of experienced maintenance engineers. Such expertise could then be preserved and deployed across the wider organization.

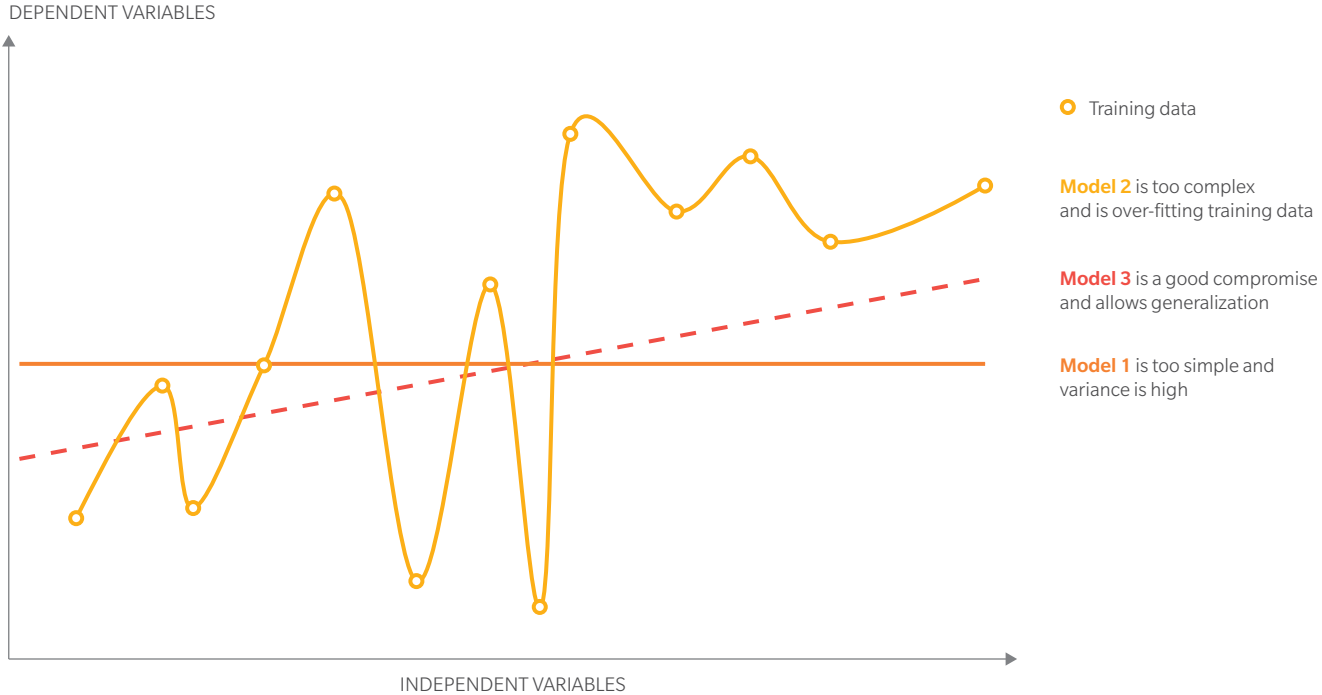
Early applications of machine learning in predictive maintenance have resulted in benefits such as better availability and reliability of assets, reduced capital expenditure (fleet size can be decreased with improved asset availability), and reduced operational expense (for maintenance hours, parts, etc.). Some of our clients have estimated that enhanced predictive maintenance could save them 20 percent or more on maintenance costs for key systems.

FROM CONCEPT TO REALITY

A fast development pace, achievements in other sectors such as retail and banking, and a growing amount of accessible data make machine learning an attractive technology for transport operators. To reap its full benefits, however, operators must understand what is different about machine learning development projects and what it takes to make them successful.

First, having large amounts of data available isn't enough. Training a machine learning model requires defining all of the factors that could influence equipment behavior. This can only be achieved through collaboration between data scientists and experienced

FINDING THE RIGHT MACHINE LEARNING MODEL



field engineers, with the willingness to understand each other's culture and mindset.

Second, data must be captured and "cleaned" to focus on those factors that specifically influence equipment behavior, such as operating conditions, temperature exposure, and prior repairs. Data does not have be perfect, however; we have found that readily available data can be used to start training a machine learning model and increase prediction accuracy (while cleaning continues in the background).

Finally, the right machine learning model for the job must be selected and trained. As models become more powerful, they also become harder to interpret. So, a simple "linear" machine learning model will deliver outputs that are easier for field engineers to use (if not quite as accurate), while complex "neural networks" will deliver more accuracy – but the models themselves are more difficult to understand.

ENGAGING IN A MACHINE LEARNING PROGRAM

The AGILE methodology, a well-tested approach for delivering machine learning projects, can help organizations realize tangible results in a reasonable timeframe. This approach involves initial iterations on a limited scope of equipment; the program is then progressively expanded as a company develops its capabilities. Early results can be used to obtain buy-in across the company and support the integration of machine learning tools across the business. To build initial momentum and enable knowledge transfer, operators might also consider collaborating with partners that have been actively developing machine learning and data science applications.

Machine learning is a promising approach for improving predictive maintenance and is certainly the wave of the future. It's time for the transport sector to consider active engagement with this technology so that it can start to realize its transformative power.

DR. KANISHKA BHATTACHARYA
Principal
kanishka.bhattachary@oliverwyman.com

JEAN-PIERRE CRESCI
Partner
jeanpierre.cresci@oliverwyman.com

PATRICK LORTIE
Partner
patrick.lortie@oliverwyman.com

EXAMPLE MACHINE LEARNING MODELS

AIR TRAVEL AND THE BREXIT TRANSITION

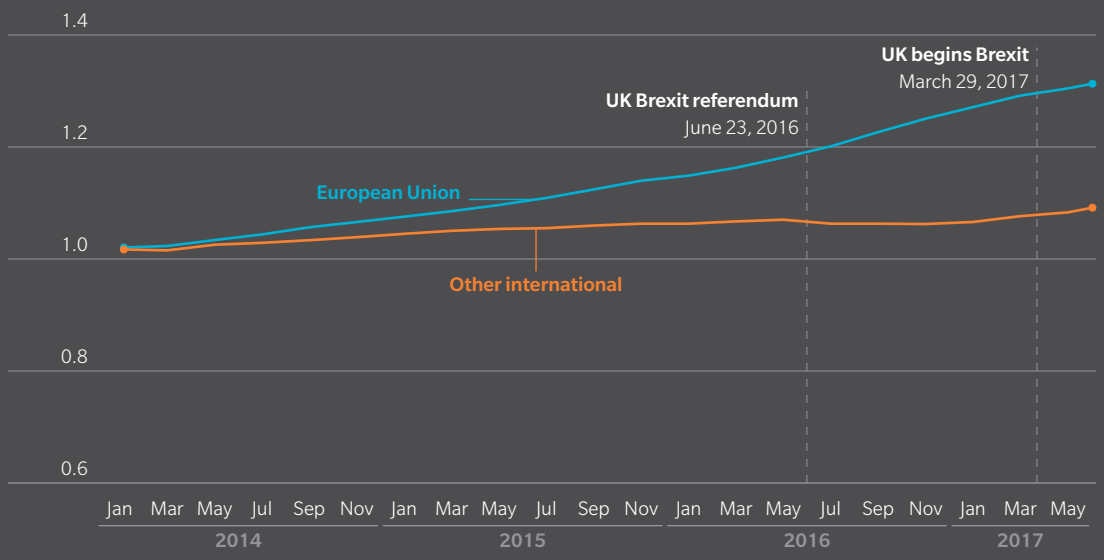
BREXIT – THE DEPARTURE of the United Kingdom from the European Union – is expected to impact many aspects of trade and travel. Oliver Wyman's Planestats.com has been tracking data on capacity and passengers to see what has been happening to airline travel from the UK to continental Europe since the marriage-ending vote.

In the months leading up to the Brexit referendum in June 2016, UK to EU capacity already had been increasing faster than for UK to non-EU markets. And UK to EU seats have increased by an additional 10.4 percent since the referendum (year-end June 2017 versus year-end June 2016). Delivery of new aircraft (ordered pre-vote) is providing the means for increasing capacity, which is occurring largely on the region's low-cost carriers (Ryanair and Easyjet), although even British Airways ramped up capacity by 10 percent this past year.

UK airlines also have seen a boost in passenger numbers on these routes. According to the UK's Civil Aviation Authority, UK to EU passenger volumes have increased by 8.7 percent since the referendum, compared to a 6.8 percent rise in UK to non-EU destinations, possibly due in part to a decline in the pound after the referendum.

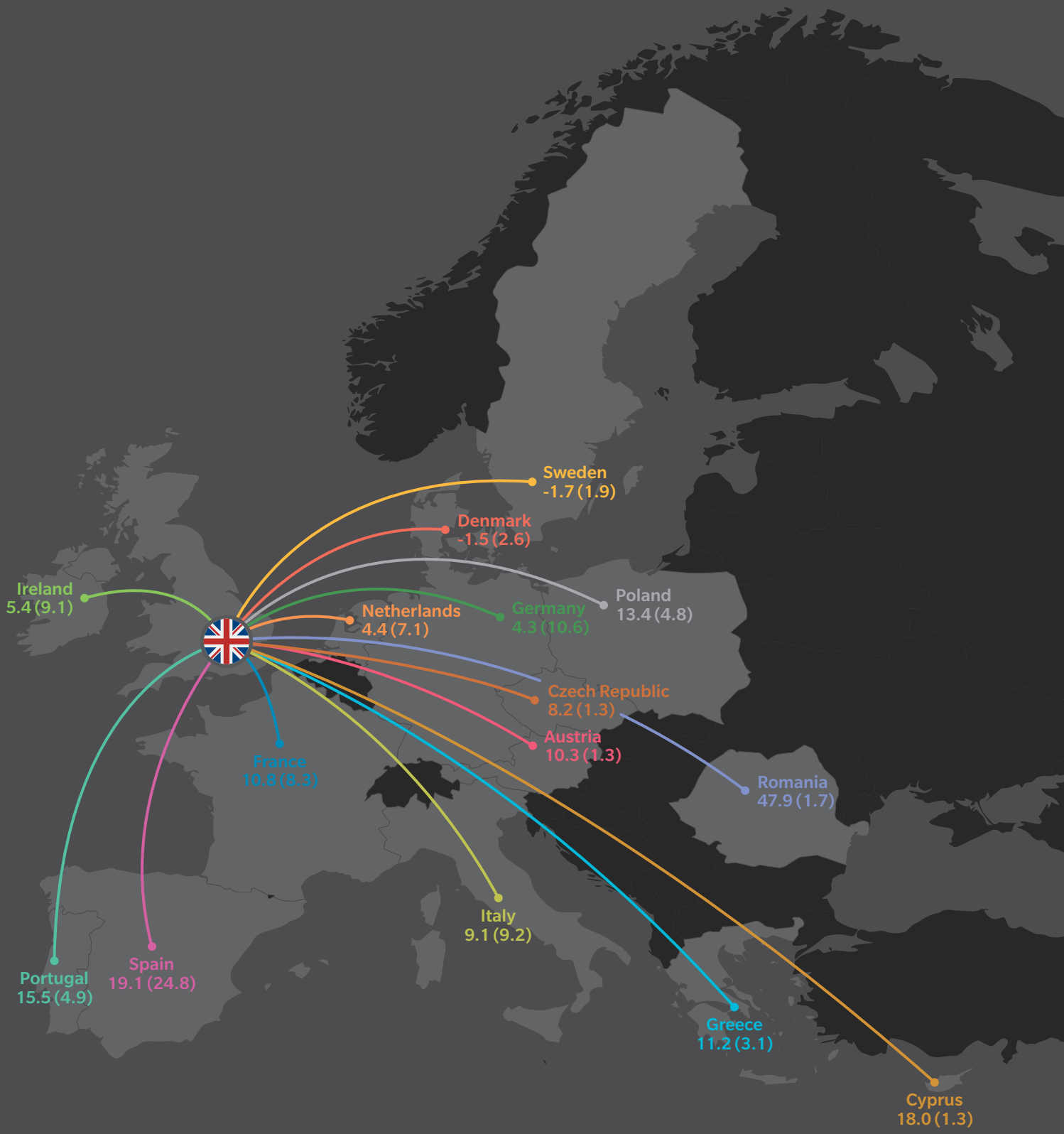
What comes next for UK-EU air travel, as Brexit proceeds, largely depends on what happens to existing EU-wide agreements – which airlines are keen to renegotiate as soon as possible. Favorable terms would mean business as usual, while limits on access or added regulation could quickly cut into airlines' bottom lines. While Brexit is not likely to cause a slump in UK travel demand, some changes may be required to address regulatory implications.

TOTAL PASSENGERS FROM THE UNITED KINGDOM TO THE EUROPEAN UNION
ROLLING 12 MONTHS, INDEX = JANUARY 2014



Source: Oliver Wyman's PlaneStats.com

SCHEDULED SEATS (CAPACITY) FROM THE UNITED KINGDOM TO THE EUROPEAN UNION
PERCENT CHANGE FOR YEAR-END JUNE 2016 TO YEAR-END JULY 2017;
TOP 15 MARKETS, PERCENT SHARE OF TOTAL MARKET IN PARENS



Source: Oliver Wyman's PlaneStats.com

AVIATION GROWTH IS OUTPACING LABOR CAPACITY

A SHORTAGE OF aviation mechanics within the next decade threatens the projected expansion and modernization of the global airline fleet. We project that the gap between the supply of mechanics and demand for them will develop in the United States by 2022 and reach a peak of 9 percent by 2027.

The problem may emerge sooner in Asia, where the bulk of growth in the aircraft fleet is slated to occur. Ultimately, the shortfall may raise the cost of maintenance for airlines and increase turnaround times for scheduled maintenance. This could potentially force the airlines to retain more spare planes to avoid cancellations and late departures resulting from maintenance delays.

The shortage is, in part, a consequence of an aging global population. Between now and 2027, a record number of maintenance technicians will be eligible to retire as more baby boomers reach their sixties. For example, in the US, the median age of aviation mechanics is 51 years old, 9 years older than the median age of the broader US workforce as calculated by the US Bureau of Labor Statistics.

And while there are plenty of people in the millennial generation who could step up and take the place of retiring workers, so far they show few signs of being willing to do so. Our projections show that the number of people leaving the maintenance technician workforce will outpace the number preparing to enter it for most of the next decade.

To some degree, the problem stems from aviation mechanics' current wages, benefits, and perks. In an Oliver Wyman survey of executives of airlines and in the maintenance, repair, and overhaul (MRO) industry, 51 percent of respondents identified wages and benefits as an obstacle. The Aviation Technician Education Council (ATEC) estimates that 30 percent of those who finish an aviation maintenance training course end up accepting employment in another industry.

OLD FLEET, NEW FLEET

The aging of the mechanic workforce and a surge in anticipated retirements could not come at a worse time for the industry, as it gears up to accommodate a larger, newer, and more technologically advanced fleet. The Oliver Wyman Fleet Forecast shows global airlines adding 10,133 planes by 2027, growing the fleet by 40 percent. This reflects purchases of 20,444 next-generation aircraft in the next 10 years and the retirement of 10,311 planes. The Asian fleet will double in size and, beginning next year, will become the largest regional fleet.

Within 10 years, 58 percent of the fleet will comprise fuel-efficient planes designed and built after 2000. Moving forward, mechanics will need a wider range of skills than ever – able to work both on the newest planes and those that have been flying for 20 years – and these are not necessarily the same types of planes. This requirement further complicates the looming worker shortage.

Tomorrow's maintenance technicians will need to be tech-savvy diagnosticians – something that was not imaginable a few decades ago. Our survey of executives identified three emerging technologies that will be vital for the next generation of mechanics to know: composite material repair and manufacture; collection and reporting of data for advanced analytics, big data, and predictive maintenance; and the newest avionics and electrical systems.

FEEDING THE PIPELINE

Sixty-four percent of the surveyed executives expect their companies to hire mechanics over the next 3 years to expand the workforce; another 23 percent say they will hire simply to maintain their numbers. And 72 percent of those surveyed expect the search for qualified candidates to get much harder.

To help mechanics develop necessary skills, 84 percent of survey respondents said their companies

were offering classes and workshops, while 61 percent said they had established partnerships with technical schools or colleges. But, since aviation competes with other industries to attract the sheer quantity of interested new hires it now needs, companies will have to look well beyond the usual tactics of opening up additional training programs.

Just as airlines and manufacturers are doing for other highly skilled positions, such as engineers and pilots, the MRO industry will have to tailor new incentives to expand and protect the technician pipeline, raise the desirability of working in aviation maintenance, and recruit across a broader demographic, especially given competition for workers with other technologically intensive industries.

We anticipate updating IT will become an increasingly important strategy to combat the impending talent shortage and help optimize operations and workforce productivity. Survey data shows that many companies are planning upgrades or migrations.

In addition, higher maintenance costs may prompt airlines to seek out more efficient MRO markets in different geographies or pursue joint ventures to lower the price tag. On the flip side, MROs, OEMs, and airlines prepared to meet this shortage challenge will be poised to win incremental business and grow over the next decade.

We believe that the current imbalance in labor supply and demand in the MRO industry eventually will be remedied by a combination of improved efficiencies, driven by new technology solutions and increased wages that will attract new technicians into the workforce. This might take a decade to achieve however, and in the meantime, both the airlines and the MRO industry will need to find new ways to cope with this challenge.

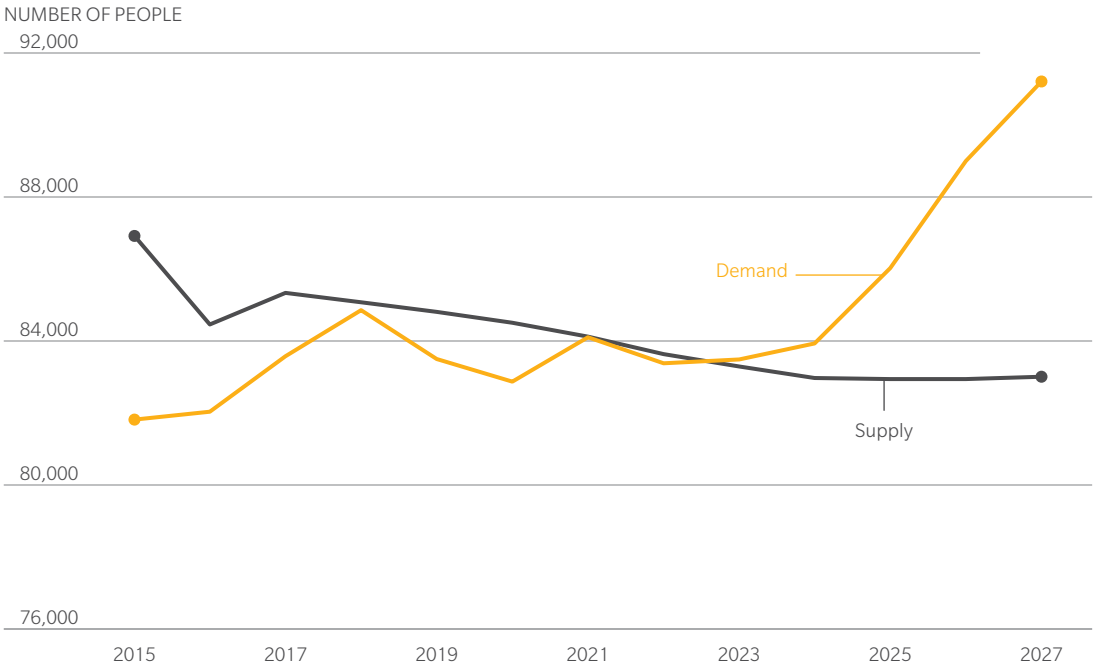
A version of this article first appeared on Forbes.com.

DEREK COSTANZA
Principal
derek.costanza@oliverwyman.com

BRIAN PRENTICE
Partner
brian.prentice@oliverwyman.com

John Smiley, a Senior Manager in Oliver Wyman's Cavok Group, contributed research and analysis upon which this article is based.

FORECAST FOR US COMMERCIAL MRO MAINTENANCE TECHNICIAN DEMAND AND SUPPLY BY YEAR



Source: Oliver Wyman Commercial MRO Maintenance Technician Labor Model

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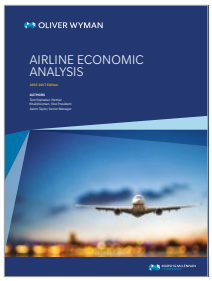

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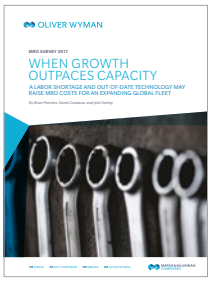

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