PreScouter

The Future of Transportation: An Autonomous Landscape

Research Support Service

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PRESCOUTER

What technologies are shaping the future of automation in the transportation industry?

Every day, there are exciting new technologies gracing the front pages of technical news sites changing the way we move goods and people. Sometime soon, new car purchases will drive themselves off the lot and head directly to their buyers, relaxed commuters will catch up on work emails while being driven to the office, and traffic accidents will be greatly reduced through automatic collision avoidance systems. With advances in autonomous control technologies, user interfaces and experiences, smart multimodal communication systems, and more, the industry is changing at a rate that is difficult to predict.

For industry players, it is a significant challenge to anticipate how all of those advances and changing technologies will resolve in the coming years. To that end, the PreScouter team has reviewed and profiled upcoming autonomous technologies across the space including UAVs, transit shuttles, cargo trains, and more.

NATILUS - Autonomous drones for cargo transport

SABREWING - Autonomous heavy-lift cargo vehicles

MATTERNET- UAV for medical products transport

RIO TINTO - Autonomous trains for cargo transport

APTIV - Autonomous ride-hailing

NAVYA - Autonom shuttle

VIRGIN - Hyperloop

ROLLS-ROYCE - Autonomous car ferry

Key Features

Not surprisingly, autonomous vehicles of all types require somewhat similar technological capabilities. Though tailored to the specific applications, the features below are widely present in the developments presented in this Intelligence Brief.

Sophisticated Control Systems

For a vehicle to move and make decisions autonomously, it must be well-controlled with an intricate system. This system will monitor and act upon communications from both the environment (V2X/V2I) and from other vehicles (V2V) along with information gained from its own systems: a complex network of sensors monitoring all infrastructure, motion, and obstacles around the vehicle.

The processing speed, sophistication, and power required for such a system is high and is made more complex with higher degrees of freedom, e.g. an aircraft can move in three dimensions whereas a car is restricted to a two-dimensional plane.

High Efficiency

Autonomous vehicles have a high potential for increased efficiency in many forms over their manual counterparts. Time savings is common across many industries, particularly with automated cargo delivery. For instance, Matternet and Natilus have developed cargo aircraft (UAVs and drones) to streamline and hasten delivery services in the medical and goods space.

Key Features

Timeliness also plays into new developments in transit speed, as with Virgin Hyperloop One's newest mag-lev commuter train. It can move at speeds of up to 670 miles per hour which will cut transit times substantially- i.e. a trip from London to Edinburgh takes 3-5 hours, but Hyperloop One could make it in 50 minutes.

Other key aspects of efficiency improvement stem from cost savings and efficient routing. Aptiv, for example, is developing a point-to-point ride hailing system that utilizes AI to analyze traffic patterns and find the most efficient routes possible both to the customer and en route to a destination, increasing the number of trips the vehicle completes. Cost savings come from elimination or reduction of necessary staff for similar operations. Unmanned aircraft (e.g. Sabrewing's for cargo transport) and marine vessels (e.g. car ferries from Rolls-Royce) allow for goods and people to be transported without staff members, which significantly reduces an operator's salary payout.

Company Cooperation

A unique aspect of these technological developments comes in the form of necessary cooperation and partnerships. Navya has developed an autonomous shuttle (aptly-named "Autonom") with successful pilot operations in collaboration with cities in 20 countries around the world. Matternet is also currently testing blood sample delivery with hospitals in Switzerland and the US. These real-world tests are necessary for successful market entrance but would not be possible without government collaboration and partnerships to support all technological aspects.

Vision of the Future

Urban commuters- *a common example and prime environment for development*

- High efficiency through route analysis and multimodal journeys
- Autonomous vehicles fight traffic to increase pedestrian and rider safety
- High population density warrants large capacity vehicles

Farming and agriculture- *shrinking a global village by making rural areas more accessible*

- Automated delivery of supplies like feed, medication, machine parts to address issues
- Deliveries are made quicker, more efficiently, and at lower cost to consumers
- Transfer of livestock and/or food products is faster to help prevent issues/spoilage
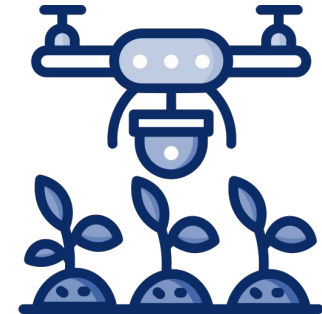
Hospital patients- *improving safety and medical efficacy through fast responses*

- Rapid movement of patients to necessary facilities through efficient transport
- Geographically diverse areas served by fast, automated delivery of medical supplies

TRANSIT

Point-to-point Autonomous Ride-hailing Transportation

APTIV

Delphi Automotive PLC, established in 1994, created a separate automotive company division in 2017: APTIV, with headquarters in Ireland. APTIV focuses in developing software capabilities, advanced computing platforms and networking architectures that are successfully contributing to produce and operate highly reliable point-to-point ride-hailing commercial driverless urban transportation. In 2018, APTIV registered a net revenue of US$ 14.4 billion.
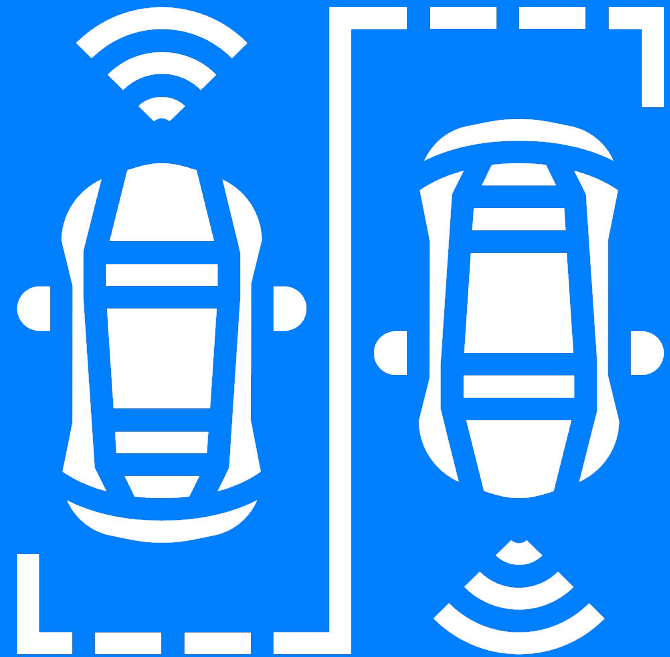
# Point-to-point Autonomous Ride-hailing Transportation

TECHNOLOGY

APTIV autonomous vehicle is characterized mainly by its unique software platform developed by APTIV's recently acquired startup company **nuTonomy**. The trademark software of the company is **nuCore**, a modular system that allows mapping, motion planning, localization. In addition, nuCore determines current weather and road conditions, and is capable of decision making and control of passenger vehicles. nuTonomy helps autonomous cars to navigate in complex traffic areas.

The software platform enables mobility through the Centralized Sensing Localization Planning (CSLP).

The CSLP uses predetermined rules for basic safe operations. Then it relies on artificial intelligence (AI) to find the optimal driving path. That is, the vehicle makes decisions using AI and reacts based on what it sees and hears, through its sensors. Radar sensors are able to operate under any weather conditions, LiDAR feeds the car with accurate range and distance information, and vision sensors provides object classification accuracy.
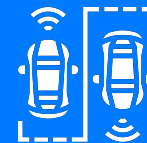
Aptiv Autonomous Driving System

- 4 short-range LiDARs
- 5 long-range LiDARs
- 6 electronically scanning radars (ESR)
- 4 short-range radars (SRR)
- 1 trifocal camera
- 1 traffic light camera
- 2 GPS antennas
- 1 Dedicated Short Range Communications antenna (DSRC)

- 2 computer and software stacks for redundancy and safety, plus ControlTec CT-Edge data communications system.
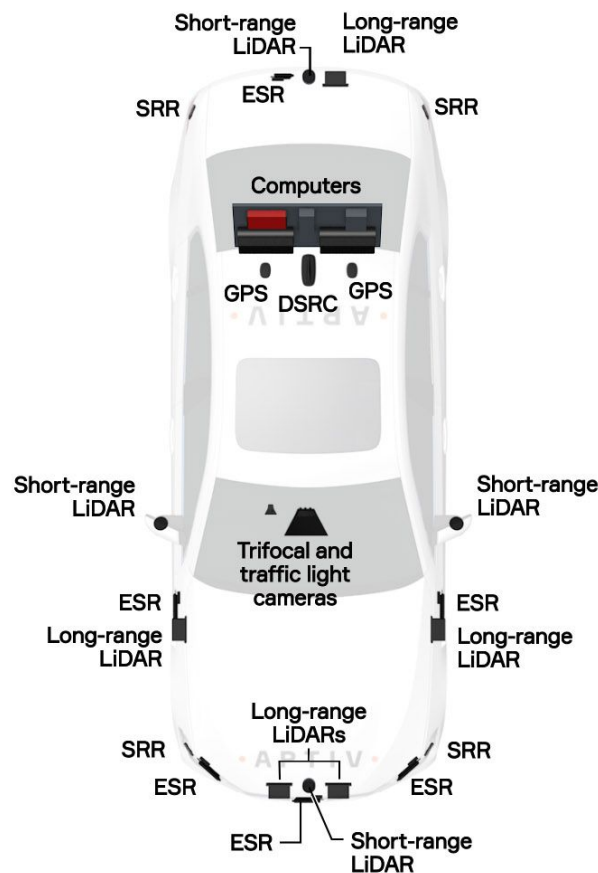
https://www.aptiv.com/images/default-source/feature-stories/aptiv-2018-ces-automated-driving-platform-1.jpg?sfvrsn=2fbf4b6d_6

·APTIV·
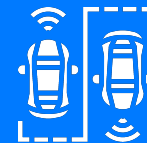
Point-to-point Autonomous Ride-hailing Transportation

ADVANTAGES

✔ APTIV's platform enables point-to-point mobility using large fleets of autonomous vehicles

✔ APTIV's autonomous vehicles are equipped with an array of sensors that allow to have a viewing distance of 240 yards and has an adaptive cruise control that accurately determine range. These features help the vehicle to operate in challenging urban driving environments

✔ nuScenes allow AI to learn more driving patterns faced during everyday challenges (i.e., heavy traffic, driving left/right of the road, differentiation of emergency public vehicles, etc.).

LIMITATIONS

➖ There is currently no approved legislation or international standardization on automotive cybersecurity available.

Point-to-point Autonomous Ride-hailing Transportation

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

Aptiv is the first company that has deployed point-to-point autonomous ride-hailing commercial services in Las Vegas, Nevada. Testing and operations are also registered in Pittsburgh, Massachusetts, Singapore, and lately in Shanghai.

Aptiv currently has provided more than 60,000 passenger rides, and passengers ratings are on average 4.97 out of 5 stars.

• A P T I V •   FULL YEAR 2017 HIGHLIGHTS

$12.9 billion revenue
UP 5% ADJUSTED FOR CURRENCY EXCHANGE, COMMODITY MOVEMENTS, ACQUISITIONS AND DIVESTITURES

$3.81
U.S. GAAP DILUTED EARNINGS PER SHARE FROM CONTINUING OPERATIONS

$4.64
EARNINGS PER DILUTED SHARE FROM CONTINUING OPERATIONS EXCLUDING SPECIAL ITEMS

$1,594 million
ADJUSTED OPERATING INCOME

$1,106 million
CASH GENERATED FROM CONTINUING OPERATIONS

12.4%
ADJUSTED OPERATING INCOME MARGIN

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Hyperloop One: A Futuristic High Speed Train

Virgin Hyperloop One (VHO) is an American Transportation Technology Company established in 2014. Hyperloop is to become a large scale reality as a mode of passenger and freight transportation able to cover long distances at significantly shorter times and low costs. To-date, VHO has been able to acquire more than US$ 400 million to continue with the project in Canada, India, Mexico, USA, and UK.
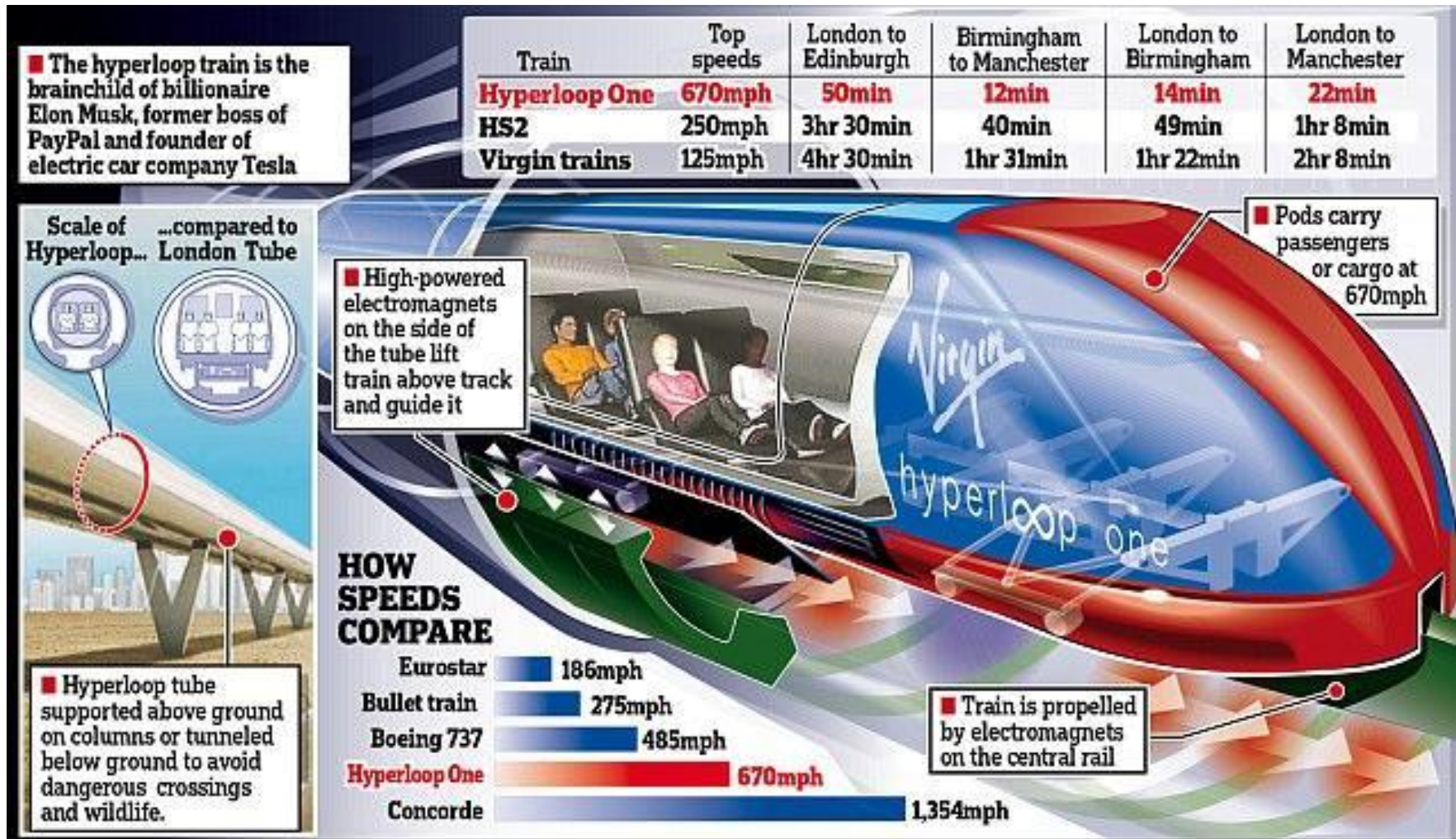
TECHNOLOGY

The acceleration of the VHO occurs gradually thanks to electric propulsion using a **low-pressure tube**. The pod is able to float above the tracks due to its magnetic levitation property. The VHO is propelled with a linear electric motor which has two main parts: a stator and a rotor. In contrast to a conventional electric motor, once the stator starts to work, the rotor starts moving in a straight line along the length of the stator. The system of the VHO operates with the stator mounted to the tube, the rotor is mounted to the pod, and the pod straddles the stators as it accelerates down to the tube.

The pod is able to glide at a speed of 670 mph.

The VHO system works under a low-pressure environment. When the VHO pod moves in the tube, the pressure rises and drops, and air flow accelerates and decelerates around it. The shape of the pod has been optimized according to the expected aerodynamic loads. Thus multiple pods are designed to depart up to several times per minute.

Hyperloop One: A Futuristic High Speed Rail

Train	Top speeds	London to Edinburgh	Birmingham to Manchester	London to Birmingham	London to Manchester
Hyperloop One	670mph	50min	12min	14min	22min
HS2	250mph	3hr 30min	40min	49min	1hr 8min
Virgin trains	125mph	4hr 30min	1hr 31min	1hr 22min	2hr 8min

- The hyperloop train is the brainchild of billionaire Elon Musk, former boss of PayPal and founder of electric car company Tesla

Scale of Hyperloop... ...compared to London Tube

- High-powered electromagnets on the side of the tube lift train above track and guide it

- Hyperloop tube supported above ground on columns or tunneled below ground to avoid dangerous crossings and wildlife.

HOW SPEEDS COMPARE

- Eurostar 186mph
- Bullet train 275mph
- Boeing 737 485mph
- Hyperloop One 670mph
- Concorde 1,354mph

- Pods carry passengers or cargo at 670mph

- Train is propelled by electromagnets on the central rail

Source: https://www.dailymail.co.uk/sciencetech/article-4974398/Virgin-announces-investment-Hyperloop-One.html

Hyperloop One: A Futuristic High Speed Rail

ADVANTAGES

✔ A faster, cheaper, safer and more efficient mode of transportation, designed to transport both people and cargo

✔ Constructed on columns above or tunneled below ground to avoid dangerous grade crossings and wildlife, with full autonomy eliminating pilot error and weather hazards.

✔ Environmentally sound, with no direct carbon emissions

LIMITATIONS

➖ Virgin Hyperloop One's tests are scantily documented (tests only documented through videos).

➖ At present, there is no axial compressor on the market with the features needed to equip a hyperloop capsule like the XP-1

➖ There are serious concerns of how attractive it could be for investors to invest in high price technology given the costs per kilometer, maintenance costs, energy consumption, etc.

Hyperloop One: A Futuristic High Speed Rail

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

In 2016, the VHO started a call for proposals to build hyperloop networks around the world. The VHO registered more than 2600 proposals selecting only 10 final test metropolitan areas in Canada, India, Mexico, England, and USA.

The current VHO plans state that the first commercial hyperloop should be ready to operate by 2021. Realistically, this may be an aggressive timeline. Many cities and countries are pushing back significantly against costly developments like hyperloop. Though the first may be ready for operation around 2021, broader implementation will likely take significantly longer- perhaps another 3-5 years.

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Autonom Shuttle

Navya is a french smart mobility company with worldwide presence and with more than 290 employees. The company has been providing its self-driving Autonom Shuttle since 2015. Navya has ~ €80 million to support its it investment in R&D so it can strengthen its technological leadership, expand sales and market its iconic products, while pursuing further international expansion.

Autonom Shuttle

The Autonom shuttle is 100% autonomous and can carry 15 passengers at an operating speed of 25 km/h. The charge of a Lithium-Phosphate battery pack lasts up to 9 hrs. It is equipped with A GNSS antenna that communicates between the GPS sensor and the base station. Its odometer measures the displacement and speed of each wheel to estimate the velocity and change in position. The external cameras detect obstacles and estimate their position relative to the vehicle, enhancing the perception maps with environmental analysis and classification.

Its LiDAR sensors provide 2D - 3D perception maps for position and obstacle detection. The shuttle counts with an onboard digital screen, SOS intercom system and 360 degree indoor camera, light signals in the exterior, and front and rear info screens, buzzer and horn.

This technology has helped NAVYA to position itself in the global market (e.g., 115 shuttles sold in more than 20 countries) way ahead of its closest competitor, EasyMile, that also develops and deploys autonomous mobility. NAVYA is currently lobbying for improved legislation for the operation of Autonom Shuttle without human supervision aboard.
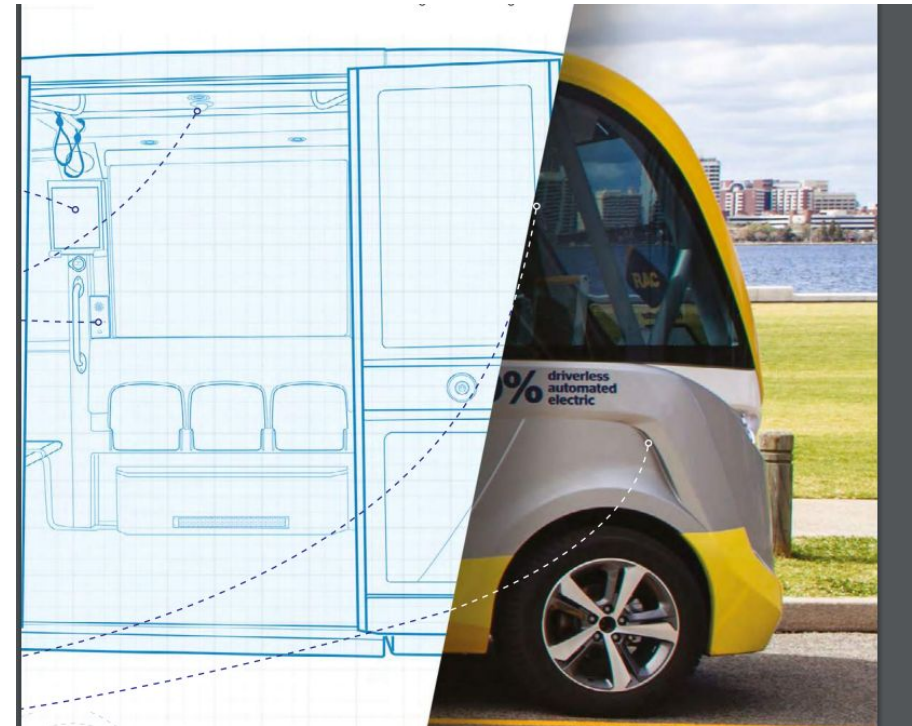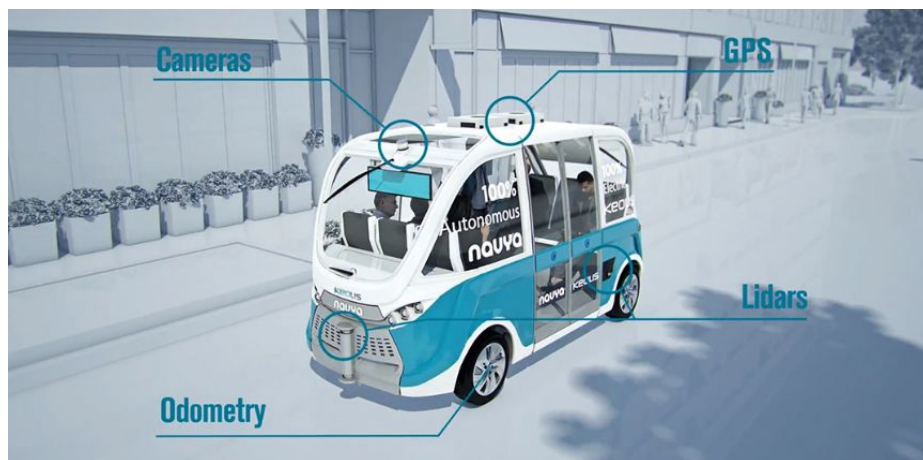
Figure: Images of the Navya autonomous shuttle

Autonom Shuttle

ADVANTAGES

✔ The autonom shuttle has broad acceptance (good feeling of safety and high levels of acceptance) with effective operations in large cities from 20 countries (e.g., USA, Japan, Singapore, Switzerland, France) with public road approvals.

✔ Ease road congestion in urban centers.

LIMITATIONS

⊖ Potential to be hacked, the driverless industry still needs to address this potential problem that can compromise the wellbeing of the passengers.

⊖ No data about shuttle sensors operability under extreme weather conditions.

⊖ As July of 2019, an accident was reported in Vienna where an Autonom Shuttle going about 7.5 miles/hour hit a pedestrian. Autonom shuttle operations has been halted until a full investigation is completed.

Autonom Shuttle

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

- Up to June 2019, Navya has sold more than 130 vehicles worldwide.

- Autonom shuttle is present in 20 European, Asia and African countries

- Before going to a large production scale, the Autonom shuttle experience over 240 test drives with 874 passengers covering over 340 test kilometres

- Navya has also started this year, the first robotized production and testing of Autonom cab. Navya has also joined venture with Charlatte Manutention (Fayat Group) to built the Autonom tract targeting industrial sites and Airports.

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CARGO TRANSPORTATION

M2 Drone: UAV for Medical Products Transport

Matternet, founded in 2011, has become the leader in urban aerial delivery. It is the first company authorized for urban drone delivery operations in Switzerland, and it has recently entered into a partnership with UPS to implement drone delivery services at US hospitals (i.e.delivery of laboratory samples). The company operates in California with a current funding of US$ 25 million.

M2 Drone: UAV for Medical Products Transport

TECHNOLOGY

The M2 drone is designed to carry payloads of ~ 4 ½ pounds over distances of up to 12.5 miles. The M2 drone has an easy-to-use interface for sending and receiving packages 24/7/365. It is controlled by using Matternet's proprietary software platform for operating Matternet networks.

The M2 Drone has the ability automatically upload the payload and exchange its battery.

A single drone is capable of receiving customer requests, generating routes, monitors, commands and controls all operating Matternet assets. The company also has integrated delivery drones to be operated automatically from a payload feeding van.

Figure: Images of the Matternet drone.

M2 Drone: UAV for Medical Products Transport

ADVANTAGES

✓ Because, it operates off-road the M2 drone's main advantage is that medical supplies, including blood products or point-of-care diagnostics and medications, can be quickly and effectively delivered to people in remote medical centers, disaster areas, and offshore vessels.

✓ M2 drones can efficiently transport organs for transplantation compared to other more expensive and weather-dependent modes of transportation

✓ M2 drones have the ability to provide medical support to the military in the battlefield.

✓ Defibrillators to patients in cardiac arrest

LIMITATIONS

⊖ In July 2019, due to serious second crash by a delivery drone, where the parachute system of the unit failed. The project in Switzerland has been halted.

⊖ First crash was reported also in Switzerland due to failure of the GPS system

M2 Drone: UAV for Medical Products Transport

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

- Matternet operates in four hospital networks in Switzerland and one in the USA.

- M2 drones have already conducted over 1,500 deliveries of patient blood samples

- Over 3,000 flights beyond visual line of sight and over people

- Matternet has been selected by the FAA to operate in the US in two projects to deliver medical samples.

- Conducted the first revenue-generating drone delivery operation in the US and in switzerland.

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Autonomous Drones for Cargo Transportation

Natilus is a large scale drone manufacturing company founded by LZ Zhang, Anatoly Starikov and Aleksey Matyushev in 2016. The company specializes in the manufacturing of Boeing 747 sized drones which provide inter-continental cargo delivery services and helps in reducing air freight costs.

Autonomous Drones for Cargo Transportation

TECHNOLOGY

Natilus's large scale aircraft drone prototype has a wingspan of 30 feet and a cargo capacity of 700 tons. This drone flies slower than a traditional freighter aircraft, thereby reducing fuel burn by 50% and also eliminating the 15% cost of crew.

The company's goal is to create 60- and 130-ton capacity freighters.

The key approach of Natilus compared to its competitors, Boeing and Airbus, is to design a vehicle meant only for air freight. That simple freighter centric approach is why the design and performance figures are so exciting to customers and is rumored to have $1B+ in aircraft orders.

Autonomous Drones for Cargo Transportation

Figure: Images of the Natilus prototype. Courtesy of Natilus.

Autonomous Drones for Cargo Transportation

ADVANTAGES

✔ Drones reduce the fuel usage by 50% compared to the traditional aircraft.

✔ Natilus is producing the largest autonomous drones that can carry 2200 lbs.

✔ The drones would not require pilots or crew thereby again reducing the shipping cost.

✔ They would launch and land on water, away from controlled airspace, avoiding the need for landing slots at busy airports.

LIMITATIONS

➖ In order to create a market for efficient, safe and sustainable commercial drones, an efficient air traffic management systems have to be developed.

Autonomous Drones for Cargo Transportation

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

- Natilus has completed the latest phase of taxi tests on water for a 30-foot-long prototype at medium-speed taxi testing in remote operation under its own power. Taxi testing was conducted in California's San Pablo Bay. The Natilus team is preparing to move towards high-speed taxi tests, followed shortly afterwards by first flight.

- The first production vehicle is scheduled for customer delivery in 2020 after undergoing wind tunnel testing.

- Natilus currently holds an aircraft order book rumored to be in excess of $1B+.

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Autonomous Heavy-Lift Cargo Vehicles

Sabrewing Aircraft Company manufactures unmanned heavy-lift commercial cargo air vehicles. It has headquarters in Camarillo, California, USA. Sabrewing creates innovative technologies at its Dragonworks Lab in Silicon Valley to develop a new era of advanced unmanned cargo aircraft.

Autonomous Heavy-Lift Cargo Vehicles

TECHNOLOGY

Sabrewing uses vertical landing and take off technology (VTOL) in its unmanned cargo aircrafts. It offers two different aircraft models – the 800-pound payload "Rhaegal" and the 4,400-pound payload "Wyvern" aircraft. Both of them come with a turbo-electric propulsion system, which uses a turbine to turn generators that then provides power for electric-adapted fans.

Sabrewing is one of the first companies to introduce the detect-and-avoid system and receive appreciation from the Federal Aviation Administration (FAA).

Sabrewing also includes a very robust detect-and-avoid system in the aircraft that provides both navigation and obstacle avoidance in the air. This technology uses turbo electric engines which do not require fuel like other autonomous vehicles.

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Autonomous Heavy-Lift Cargo Vehicles

Figure: The Sabrewing Rhaegal aircraft

Specifications of Rhaegal					
Wingspan:	10 m / 33 ft	**Turbine Model:**	M250-C47E	**Cruise Fuel Consumption**	65 kg / 144 pph
Length:	8.56 m / 28 ft	**Turbine Power (max take off):**	523 kW / 700 hp	**Fuel Type**	Jet - A
Height:	3.66 m / 12 ft	**Turbine Power (max continuous)**	447 kW / 600 hp		

Autonomous Heavy-Lift Cargo Vehicles

ADVANTAGES

✔ No runway is required with the vertical landing and take off technology

✔ The Rhaegal can operate in extreme weather conditions

✔ Maintenance is east with no special training, parts or fuel needed

✔ Easy ground transport and storage with foldable wings

✔ The turbo electric power train is highly efficient with no requirement of a charging station

LIMITATIONS

➖ The technology is in its nascent stage and requires more time to realise the product and commercialize it.

Autonomous Heavy-Lift Cargo Vehicles

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

- Currently the company is focused on developing the Rhaegal with a cargo capacity of 800 pounds, a range of 360 nautical miles and a maximum altitude of 22,000 feet for testing in airspace around St. Paul Island in the Bering Sea.

- Sabrewing is on the verge of creating partnerships with three other companies to initiate the process of manufacturing the VTOL aircraft.

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Autonomous Ships for Cargo Transportation

Rolls-Royce and Finnish state-owned ferry operator Finferries have demonstrated the world's first fully autonomous car ferry named FALCO in the archipelago south of the city of Turku, Finland. Rolls Royce sold its autonomous maritime division to Kongsberg, an international technology company.

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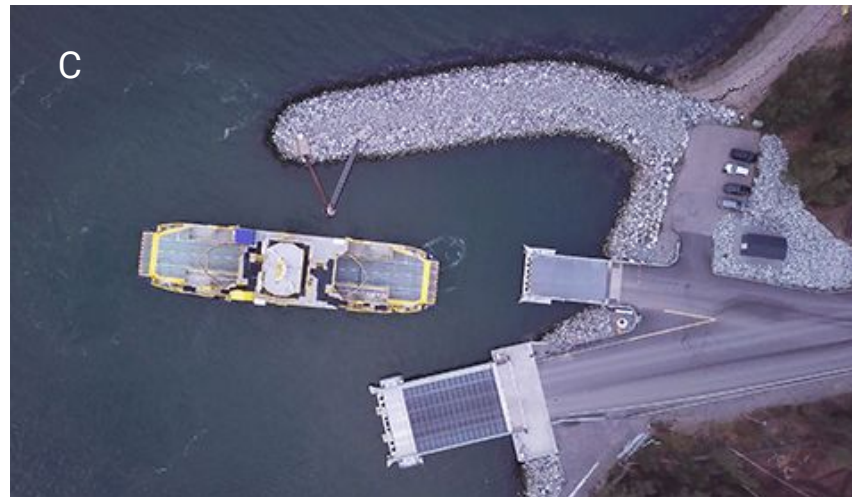
Autonomous Ships for Cargo Transportation

TECHNOLOGY

The autonomous vessel FALCO detects objects utilising sensor fusion and artificial intelligence and conducts collision avoidance. It has automatic berthing with a recently developed autonomous navigation system. The main difference between autonomous ships and cars is in the steering, where constant monitoring is required for the car's movement. For ships, the environment needs to be constantly monitored rather than the ship's trajectory.

The FALCO is equipped with a range of advanced sensors which allows it to build a detailed picture of its surroundings, in real time and with a level of accuracy beyond that of the human

The situational awareness picture is created by fusing sensor data, and is relayed to Finferries' remote operating center on land, where a captain monitors the autonomous operations, and can take control of the vessel if necessary.

A. Rolls Royce unveils the concept for remote-controlled ship; B,C. Images of Rolls Royce testing its first autonomous ship

Autonomous Ships for Cargo Transportation

ADVANTAGES

✓ Cost reduction eliminating/reducing the crew

✓ Remodelling the ship to gain efficiency without crew

✓ Autonomy reduces the human risk and error

✓ Reduces the risk of employee harm from piracy

LIMITATIONS

− Safety concerns need to be addressed especially with the enormous size of the ships in congested waters

− Regulations yet to be sorted out for the autonomous vessels to be fully operated without crew

− Insurance and other legal issues are yet to be addressed

Autonomous Ships for Cargo Transportation

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

- Rolls-Royce, partnered with Finferries, demonstrated the world's first fully autonomous ferry in the archipelago south of the city of Turku, Finland in December 2018.

- The demonstration was conducted under fully autonomous control with 80 invited VIP guests aboard.

- Rolls Royce and Intel are intending to collaborate to design sophisticated intelligent shipping systems that will make commercial shipping safer.

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Autonomous Trains for Cargo Transportation

Rio Tinto is a leading global mining group with headquarters located in London, UK. Rio Tinto's AutoHaul project successfully achieved a significant milestone with the first delivery of iron ore by an autonomous train in the Pilbara in Western Australia in July 2018.

Autonomous Trains for Cargo Transportation

Each AutoHaul locomotive is fitted with an onboard module which sends automatic reports on its position, speed and direction of travel to the control centre located more than 1,500 km away in Perth, and the locomotives and all public crossings are also fitted with cameras allowing constant monitoring. The $940m AutoHaul programme is focused on automating trains transporting iron ore to Rio Tinto's port facilities in the Pilbara region of Western Australia.

The network is the world's first heavy-haul, long distance autonomous rail operation.

Rio Tinto operates about 200 locomotives on more than 1,700 km of track in the Pilbara, transporting ore from 16 mines to four port terminals.

Figure: The Rio Tinto AutoHaul™ train in action

Autonomous Trains for Cargo Transportation

ADVANTAGES

✓ Autonomous trains improve safety greatly through reduced risk at level crossings and automated responses to speed restrictions and alarms

✓ AutoHaul™ also removes the need for almost 1.5 million kilometres of road travel per year that was previously required to transport drivers to and from trains mid-journey.

✓ All locomotives are fitted with AutoHaul™ safety systems such as Collision Detection Systems (CDS), Automatic Train Protection (ATP) technology that controls train speed to ensure adherence to speed limits and an on-board video camera to record the front view from the train.

LIMITATIONS

− Though the train controller sets the route at the Operations Centre which is 1,500 kilometres away, the on-board computers and the computers at the Operations Centre take over the train once it starts and makes its own decisions. This can be dangerous when a problem should arise with a computer.

Autonomous Trains for Cargo Transportation

COMMERCIAL TESTING / IMPLEMENTATION / PLANS

- Rio Tinto completed the first fully autonomous rail journey without an engine driver on board in October 2017.

- With the $940 million rail project, titled AutoHaul, Rio Tinto successfully rolled out its automated rail network to transport iron between Rio Tinto's various port facilities in Pilbara, Western Australia.

References:
1. https://www.riotinto.com/media/media-releases-237_27489.aspx
2. https://www.railwaygazette.com/australasia/rio-tinto-completes-autohaul-autonomous-train-project/47822.article
3. https://www.riotinto.com/ourcommitment/spotlight-18130_25692.aspx

Next Steps

| Topic	Question	Report
Outreach	Outreach to targets of interest in the UAV/cargo space- Sabrewing, Matternet, and Natilus	IB 2
Company Highlights	Provide overview documents on companies of interest to share with others at [client organization].	IB 3

Next Steps

**THESE ARE SOME POSSIBILITIES THAT PRESCOUTER CAN OFFER
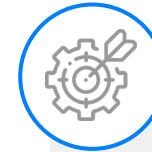FOR CONTINUATION OF OUR RELATIONSHIP:**

PERIODIC TRACKING OF NEW DEVELOPMENTS: quarterly/biyearly scouting on any novel technologies related to the topic of interest.
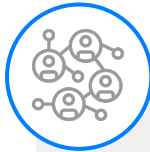
OUTREACH to companies or research groups for detailed anonymous interviews.

Engagement with **SUBJECT MATTER EXPERTS** to receive an expert opinion.

Engaging with a **CONTRACT RESEARCH ORGANIZATION** for building a prototype, testing an equipment or any other related research service.

CONFERENCE SUPPORT: PreScouter can attend conferences of interest on your behalf.

WRITING ARTICLE: PreScouter can write technical or more public facing articles on your behalf.

For any requests, we welcome your additional questions and custom building a solution for you.

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About the Authors

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Professional Summary:

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Paula has been leading projects with PreScouter since 2015, working extensively in areas such as new materials, product and process improvement, performance coatings and surface treatments, and landscaping new developments throughout the transportation industry. Her main scientific interests include organic electronic devices, sustainability technologies, and smart cities. Paula completed her undergraduate degree at DePaul University and her PhD at the University of Pittsburgh. She is based in Denver, CO.

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Professional Summary:

As a scientist, Jorge aims to study sustainability and development issues that can generate positive changes in the lives of local communities. Jorge finished his Master's degree in Tropical Conservation and Development from the University of Florida and completed his PhD in Biology at Syracuse University. Jorge is based in Canada, where he was until recently, working for Environment and Climate Change Canada. Jorge has lately become more involved in communicating science to specialize and general audiences, and still diverges most of his efforts to work as an environmental consultant and to teach kids the need to keep in touch with nature.

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Vijetha completed her PhD in the domain of Inorganic and Analytical Chemistry. Her main research contributions have been to analyze novel inorganic ligands, nanoparticles, and ionic liquids to be used as tools in nuclear waste management, biomedical imaging, and separation chemistry. Her recent work contributed to the successful development of a greener pathway to recover strategic metals from end-of-life Ni-MH batteries.

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