

Scope

My project is about Harley Davidson shaping the future of motorcycle transport. Creating a hover bike for the year 2030. The bike will be an interim concept while the technology and infrastructure for flying bikes is still being developed which is targeted for the year 2050.

The bike can either be used in cities like New York for commuting and traveling to local areas or for fun rides on the weekend more like traditional Harley Davidson motorcycles. This bike shouldn't look out of place parked at a biker's café surrounded by other motorcycles and enthusiasts.

It will also be used as a training tool at demo days and bike training schools around the world. This is a way to introduce people to the idea of transportation off the ground, Harley Davidson plan to diversify their brand into producing solely electric bikes and designing the future of hover bikes, this is the first step at introducing hover bikes to public streets.

Environment

Target environment will be city centres like New York, the current problem with large cities are emissions, noise and traffic pollution. This bike is a way to target and combat all three. It will be electric and aimed in the market as a replacement for internal combustion engine vehicles, this will help contribute towards cleaner air zones in large cities. Noise is a large disrupter in cities, the constant rumble of engines, the drone of tyres on the tarmac as they go past and the aggressive honking of horns. By creating an electric propelled vehicle that no longer need to stay in contact with the ground it will become one of the most peaceful vehicles to use within a city environment. Road maintenance could be compared to a dog chasing its tale, it's a never-ending task for the city worker. From the repeated abuse of heavy vehicles, the life expectancy of a city road is short, cracks and potholes appear in a matter of months but by elevating the vehicle above the ground roads won't take as much abuse. With a hover vehicle roads do not need to be 100% smooth. Tyres are a consumable part to every road vehicle; this is unsustainable for several reasons. Tyres are non-recyclable and cannot be disposed of after use creating large amounts of environmentally damaging waste. The second point is tyres can be very pricey, with the life expectancy of around 15-20 thousand miles, this means over the life cycle of a traditional road vehicle it is guaranteed to consume multiple sets.

This is a way to commute with zero impact on the city environment. Electric population to reduce emissions. Smog and emissions are a major problem in all large cities now and this is a step towards mitigating it.

My IF Design Student Award Targets

Sustainable Cities And Communities

For the target year of 2030 there are several goals to achieve, this bike will help achieve these. As cities grow, they become overcrowded and polluted, green land is replaced with buildings and tarmac roads resulting in limited public space and with poor planning huge slums appear, tangled traffic and sprawling suburbs. By reducing vehicles on the road that require smooth tarmac and creating the hoverbike it could make some tarmac roads redundant leading to increased public space, making socialising and outdoor activities more accessible. By reducing tarmac in cities, it will also improve drainage and help prevent flooding.

The Harley hover bike is the first step in city travel that is no longer reliant on smooth tarmac roads, it is designed with the future of the city in mind focusing on sustainability and being economically friendly. The bike will have minimal consumable parts in an effort to increase sustainability, it won't have tyres that need to be replaced, no brake pads and no engine oil plus filters. This is due to the electric powertrain not having any consumable parts and can be charged using renewable energy sources like wind, solar also by hovering above the ground, tyres and wheels would be surplus to requirements.

Industries Innovation And Infrastructure

Smart Transportation: transportation networks are becoming more integrated together via Wi-Fi and AI updates, they can now communicate with each other remotely without any human intervention. The number of driverless cars on the roads is set to increase with inventions like the new Tesla Robotaxi (Tesla, 2024) and traffic controls becoming automated. AI-powered navigation systems in the vehicle/ smart phone can optimize routes and schedules in real time, reducing travel time and public transport delays while consuming less energy.

In large cities smart transportation systems will include hover bikes, these will be smart airborne vehicle using advanced technology to navigate urban environments. Some of this tech includes eVTOL technology (Stanzione, 2019) which means electric vertical take off and landing. There are several advantages to incorporating hover bikes into the city's developing transportation system, especially in terms of last-mile connection, traffic reduction, and quicker access to crowded or difficult-to-reach locations. A hover bike will fit into this idea in the following ways:

Last Mile Connectivity:

Efficient Urban Mobility: Getting from public transportation hubs (such as bus stops or subway stations) to final destinations is one of the largest issues in contemporary cities. For this, hover bikes might offer a quick, adaptable, and environmentally responsible alternative. Imagine skipping congested streets and lengthy walks by taking a hover bike from a subway station to your apartment or office building in a matter of minutes.

On-Demand Service:

Like ride-sharing applications currently function, hover bikes may be available on-demand. Using a smartphone app, users could signal a hover bike by indicating where they were going, and a hover bike would come to a landing pad nearby to pick them up. They could then ride these motorcycles straight to where they wanted to go, avoiding all traffic.

Shared Infrastructure:

Just like today's bike-sharing docking stations, hover bikes would require specific landing pads and charging stations spread out around the city. To facilitate hover bike access, these could be positioned strategically close to transportation hubs (such as major bus terminals, metro stations, or office areas). For uniformity and effectiveness, charging infrastructure would probably be incorporated into already-existing networks for electric vehicle charging.

Autonomous Hover Bikes:

Although hover bikes are probably going to start out with human pilots, autonomous hover motorcycles may become a reality in the future. Hover bikes may be able to travel on their own by 2030 thanks to NYC's AI-powered transportation networks, which connect to other airborne vehicles and intelligent traffic control systems via V2X technology (www.rohde-schwarz.com, n.d.). To avoid crashes and lower the chance of air traffic jams, these systems optimise vehicle's departure and flight paths.

Climate Action

The long-term objective is to be carbon neutral by the year 2050, with 2030 acting as a milestone to make sure we are on track to achieving this. In places like New York with the 2019 Climate Mobilization Act, (Highlights of Local Law 97, n.d.) a plan is already in place for the city to follow to make sure its meeting carbon reduction targets and on track for carbon neutrality for the year 2050.

“-Reduce New York City’s overall emissions 10 percent by 2030

-Eliminate 6 million tons of greenhouse gas emissions by 2030, the equivalent of taking 1.3 million cars off the road every year

-Create 26,700 green jobs by 2030

-Prevent 50 to 130 premature deaths annually by 2030

-Prevent 150 hospital visits annually by 2030” (Highlights of Local Law 97, n.d.)

Environmentally Friendly Transportation

The hover bike is going to run on an electric propulsion system which can be charged using renewable energy. This means a significant reduction in carbon emissions compared to traditional ICE (internal combustion engine) vehicles. Large cities like New York targets have been set for sustainability and to be carbon-neutral by 2050, the hover bikes will fit perfectly into this vision. By 2030 hover bikes will be part of a large fleet of electric zero-emission vehicles on the ground and in the air.

Noise Pollution Management: Since traditional drones and airborne vehicles may be noisy, noise pollution could become a problem with hover bikes. But improvements in silent propulsion technologies (such electric ducted fans) (www.sciencedirect.com, n.d.) will mitigate this issue and make it possible for hover bikes to be utilized more successfully in cities without making too much noise. To prevent hover bikes from interfering with daily life, particularly in residential areas, cities will carefully monitor noise levels.

Need For Vehicle

In urban environments like New York City, there is a need for hover vehicles due to a combination of transit issues, environmental concerns plus recent future technical developments. The traditional forms of transportation like cars, buses, and subways are coming under strain and struggling to keep up with the growth of the city. As cities expand transportation routes become more complicated and congested. However, hover vehicles could prove to be an essential solution to in the future for the following reasons:

- 1.Reducing Traffic Congestion
2. Last-Mile Connectivity
3. Environmental Benefits
4. Faster Travel Times
5. Access to Hard-to-Reach Areas
6. Innovation in Urban Mobility
7. Emergency and Specialized Services
8. Reducing Noise and Air Pollution in Urban Areas (EASA, n.d.)
9. Space Efficiency and Infrastructure Use
10. Advancing Urban Air Mobility (UAM)

This vehicle is an introduction to the future of transport. Travel in the future will be on multiple levels, this will relieve stress on traditional ground level public roads and create a safer means to travel. It is an important step towards introducing off the ground travel to the public. As one of the first elevated means to travel this bike will pave the way for future vehicles. The next generation of hover vehicles is set to be a replacement for traditional motorbikes and solo travel car journeys. This vehicle will be needed to gain the public's trust in hovering transport, debuting at multiple demo days and riding schools before making an appearance on public roads. The hoverbike will require a new type of driving licence due to its difference to all current types of transport.

Harley Davidson is the suitable brand to launch this bike due to its deep history in two-wheel transport and its forward thinking approach to new electric propulsion systems in motorcycles. Harley have invested a lot of time and resources into developing the optimum way to produce electric motorcycles.

Vehicle Benchmarking

Current hover bike examples:

Hoversurf with the Hover Scorpion, a Russian company who have produced a functioning concept. The bike is a single seater quad copter it has a top speed of 43 mph and a max elevation of 15ft due to restrictions programmed into the software, a range of 13 miles or up to 45 mins of flight time. The bike uses lidar and the pilot to set the desired altitude and the bike will hold that height, it is powered by electric motors and batteries to four propellers. (evtol.news, n.d.)

Malloy Aeronautics Hoverbike, this uses 4 electric motors to power 4 propellers with a carry capacity of 1 pilot over a maximum range of 125 miles with a maximum speed of 60 mph. The construction materials are aircraft-grade aluminium, UV-stabilized polycarbonate and carbon sheet. (chris.malloy, n.d.)

Lazareth LMV 496 - Transforming Jet Hover Bike powered by 4 jet engines that create a total of 1300bhp combined with the kerosine fuel tank to allow for 10 minutes of flight. This can also be

ridden as a 4-wheel motorcycle powered by a 470hp V8 Maserati engine. The bike can hover 3.3ft above the ground. (<https://www.facebook.com/adamgraycars>, 2024)

I am looking at current concept and what they offer to decide what mine can improve upon. Currently hover bikes are not appropriate vehicle to use alongside city traffic, mine will break this tradition and will be designed specifically for this purpose. As technology improves the size of the propulsion equipment will shrink and become more efficient. Current hoverbikes have small batteries and a short run time.

Using the current statistics of hoverbikes it's obvious where improvements can be made. The Harley Davidson will be efficient enough to measure in miles instead of minutes with a total range of 100+ miles. The materials used will be carbon fibre and aircraft grade aluminium and the propeller size will be more compact to allow for a smaller sized vehicle. Current hoverbikes can only carry one rider due to a lack of power but the Harley Davidson will easily handle a crew of 2 riders, increasing the bikes practicality.

Infrastructure + Technology Study

Due to the adversities of a hover vehicle some adjustments will be made to the infrastructure, initially the bike will be released to the public via riding learning facilities, interactive pop-up events and flying demonstrations. These events will allow customers to experience the thrill of flying a hoverbike firsthand, test rides and private flying lessons will provide experience to encourage potential buyers.

After this the bike will be used on public roads. Another benefit of hover transport is it doesn't require a smooth tarmac road for comfortable rides. This will mean it's not confined to only being used on public roads. The technology for full flying bikes isn't currently ready but will be by the year 2050.

Currently hoverbikes are achievable by the year 2030, the first generation will be using cutting edge technology with more efficient battery designs that are more compact than the ones current produced. This inevitably reduces the weight and increases the range. Advances in Propeller designs creates a higher efficiency to size ratio, allowing for the reduction in size compared to current production hover bikes. Another advantage of having smaller diameter propellers is increased manoeuvrability of the bike, this is great for city roads due to the reduced size of the overall package.

Scenarios

Setting- It's a busy morning in New York City in 2030. The city is a dynamic hub where technology and infrastructure are evolving to meet the needs of a connected and sustainable urban environment. Hover bikes have become integral to the city's transportation ecosystem.

Emma, a professional working in the Financial District of Manhattan. She lives in the Brooklyn Heights neighbourhood and needs to commute to her office every day. Emma will have to commute within the city, carrying a bag of work equipment such as files and laptop. She's been using her hover bike for her daily commute because it offers faster travel times and a convenient way to avoid the chaos of subway delays and traffic jams. When she arrives at her office building in Lower Manhattan, she lands effortlessly and parks her hover bike at one of the designated charging and docking stations.

Lily, a first responder EMT paramedic who needs to get to an emergency site in a busy area of the city. There is a critical emergency in the heart of Times Square, where a pedestrian has been hit by a car. Traffic is severely congested, and traditional emergency vehicles are stuck in gridlock traffic. However, Lily can reach the scene quickly and weave around the traffic using her emergency hover bike, reducing response time to the patient.

Jon, a delivery driver working for Royal Mail company. His route involves delivering packages quickly across the city. Royal Mail has a fleet of hover bikes with cargo holds on the back to travel around the city to deliver letters and small parcels efficiently. The dashboard navigation system can plot the most efficient route reducing delivery times.

Clive, uses his hover bike for traveling to the local sports centre/ gym and collecting a small shop from the supermarket, this is both a fun and efficient method for Clive to execute his daily routine.

User Study

The main target user is anyone aged 17 and over who need to commute or travel for leisure further than a steady walking distance. Another example of the target user; Clive Smith aged 23 who lives in a town 15 miles outside of Birmingham city centre, which is where he works. He is also an active person when enjoys hiking and working out at the gym. The bike is suited to Clive because he regularly needs to commute inside a clean air zone (Birmingham city centre) a tax is required if your vehicle doesn't meet clean air regulations, this bike will meet these requirements.

It will also target Harley Davidsons existing customer base, as a fun toy to use on weekends and go for group rides on. It is vital to get the approval of the current target market to keep Harley Davidson current reputation and prevent losing a loyal fan base. To the user Harley Davidson is more than just a bike brand, it's an expression of their personality, it stands for freedom and adventure. The target audience is forward thinking, technologically inspired and willing to embrace change. The type of consumer who would normally travel via motorcycle or push bike.

Design Direction

Aesthetically it will look sleek and futuristic but not too dissimilar from a conventional motorcycle. There will be storage compartments under the seat and pannier storage at the back.

My design will take inspiration from historic Harleys using the iconic design language. By a design shaped mostly from functionality and will incorporate traditional Harley design cues and colour schemes to make it easily identifiable. It will be similar proportions to traditional motorcycle in length, width and saddle height. My hope is to create a distinctly familiar design with a futuristic modern approach.

Harley Davidson design cues:

Triangular frame- all Harleys maintain the iconic wedge frame design, high at the front and a low-slung rear, early bikes like the hardtail (Spike, 2023) don't feature rear suspension which is what created the shape for all Harleys of the present to maintain. Now the modern Softail does have rear suspension, but it's shaped in a way to mimic the design of early bikes. The hover bike won't need rear suspension, and the design will take inspiration from these traditional bikes.

V twin engine- a crowing feature for Harley Davidson is the engine, they have always had a distinctive look and sound. Unfortunately, the hover bike will not sound like a Harley, but the batteries and motors will be situated in a way to pay homage and resemble the v twin shape.

High front end, low saddle- renowned for having high rise handlebars and suspension leather saddles. The bars are mostly for fashion purposes to accentuate the distinctive shape of the bike and give the rider a sit back cruising stance. The leather seat was created because of the abundance of leather from cattle farms across America, the country of Harley Davidsons origin. Leather is also a highly durable material that can be easily moulded and is non soluble. The springs on the saddle increase ride comfort offering a small amount of cushioning, without rear frame suspension it causes a bumpy uncomfortable ride but by adding a small amount of damping to the saddle it improves ride smoothness.

Round headlamp- face on Harley Davidson's can be identified by a large round headlamp centred between a set of chrome front forks, like other characteristic of the brand it's a case of form following function but as technology has progressed, they have maintained this design. New models have LED internals instead of old-fashioned bulbs.

Chrome- famous for mirror chrome on all the bike's accessory parts. Chrome is an old way to make Steele more weather durable. It also creates an attractive high-quality appearance to the bikes. A lot of aftermarket parts are available and its not uncommon to see a fully chromed bike riding down the street, all parts from forks, bars, frame and even the engine can be polished up to a mirror finish.

Orange and black colour way- although the logo has recently been changed to a monochrome design historically it featured the contrasting orange and black colours. The Harley Davidson logo stands for more than just a bike brand, the logo now represents adventure freedom and soul (Harley-Davidson, 2023). By wearing an item of clothing that includes this logo you are indirectly expressing yourself and lifestyle. When you think of this brand you also associate vivid metal paintwork, specially on the tanks of their bikes.

Together this design language creates a robust, powerful aesthetic, which the hover bike will maintain. Where the hoverbike will diverge from the norms of Harley Davidson design will be in material use, focused on aerodynamics and embodiment of its drone capabilities. The materials used will be aerospace grade metal and carbon fibre (ntrs.nasa.gov, n.d.) to keep mass of the bike as low as possible, this material will have a substantial, robust appearance. The bike will not try and hide the fact it is a form of drone, instead it will make a feature of what propels it using the powertrain as a focus point of the bike. By doing this it follows Harley Davidson design philosophy with sharp sleek industrial design, embracing the mechanics of their bikes.

Inspiration

Design inspiration is from Harley Davidsons vast history combined with modern design concepts. Considering the brands ideology for future design, focusing on seamless integration of technology within the bike. My design thesis is form follows function, prioritising usability and function, that is not to say my design will look like a styleless industrial machine.

A large amount of inspiration is from the environment of its intended use, the streets of New York are filled with stylistic architecture like the flatiron building with its renaissance

architecture (New York City Tourism + Conventions, n.d.) and the Chrysler building with its art deco architecture, both iconic staple of the city, filled with character on abstract style.

Influence from American culture, Harley Davidson is as much a motorcycle brand as it is an expression of what it means to be American. (Vargas, 2024) The first bike was produced in 1903, 121 years ago cementing itself into the US history books, my design will capture the sense of freedom and angst that comes with the logo.

How Does It Work

The hover bike works by using a combination of cutting-edge technologies to achieve vertical take off and landing (VTOL) also allowing it to hover above the ground and fly like a small aircraft. Essentially, it's a combination between a drone and a motorcycle, built for personal transportation, and powered by electric propulsion.

The hover bike's key components and technology are:

Multiple electric powered motors with a large rechargeable battery, used to power four propellers inspired by drone technology for adequate stability, fast acceleration and sharp braking. The operating system will have a programmed in height restriction of 1 metre to maintain safe travel not too high up and the functionality of a hoverbike. Initially the bike will use existing infrastructure in cities such as main roads and highways. But it will also be able to travels where average road vehicles cannot. The extra areas the hover bike can travel will be across rough, uneven terrain and over water, it will be able to take a more direct and efficient route to the destination. By travelling across these surfaces, it won't need the same level of high maintenance infrastructure that traditional transportation methods need, like bridges and smooth tarmac roads.

Drivetrain

Looking at the benchmarks my chosen powertrain will be four electric motors paired with a large battery to power four ducted fans, the four fans will create stability and enough lift to propel it, the vehicle will change direction by adjusting prop angles accordingly.

Power- 200bhp

Top speed- 110 mph

Range- 150 miles

Battery size- 20 kwh

Proportions- seat height- 30inches / -width-40 inches / -length-90 inches / -weight- 200kg

Battery type- lithium ion

After some educated research this is the specification that will best suit the vehicle. Power will be 50bhp per electric motor to provide enough lift and braking power to travels at road going speeds and have a faster than average acceleration. Top speed will be restricted by electric cable size like currently produced EV motorcycles. The bike is aimed for shorter travel distance, with a range of 150 miles there will be no range anxiety for day-to-day use and with a rapid charger it will take 30 minutes to achieve 80% charge (www.bppulse.co.uk, n.d.). This is more than enough for its intended purpose of city commutes, for a longer range it would require a larger battery which would inevitably increase the overall mass of the bike making it less

manoeuvrable. The dimensions of the bike are based off the current production Livewire models, proven to be an adequate size for urban road use.

Performance is not the target for this vehicle, there is a vast number of modern bikes that target performance, and the market is saturated. The main target for this project is sustainability and safety, two aspects that I feel are often neglected in motorcycle manufacturing and the main reason motorcycles do not appeal to the mass market.

Safety Features

Given the unique nature of a hoverbike, safety will be paramount. Key safety features will include:

AI-powered collision avoidance systems- used to detect and avoid obstacles in real-time. One of the biggest causes for collision and accidents in urban environments are obstacles entering the road as you approach an area. By having AI avoidance technology, it will be constantly scanning the terrain ahead for potent hazard awareness and can predict dangers that the rider may not be aware of. (Mobileye.com, 2024)

Redundant motor systems- Will be used in emergency situations. If one motor fails, this will ensure the hoverbike remains stable and does not lose control. In this case it will function by diverting partial power from an alternative motor to allow for a controlled reduction of speed and safe landing. (Orscheln Products, 2022)

Emergency landing protocols- an AI controlled system that will guide the hoverbike to a safe landing if the system detects a failure.

Helmet and protective gear- Just like a traditional motorcycle where specialist gear is required or highly recommended the hover bike will require its own set of safety gear. This will be designed in collaboration with established motorcycle safety divisions to ensure both comfort and protection for the rider.

Harley Davidsons Current Vision

Harley Davidsons have been given an 89 million dollar grant from the government (Civicmedia.us, 2024) to further their future in electric bike production, they believe there is a high demand for electric vehicles. With this money they intend on accelerating the production of more affordable and faster charging EV options and they plan on doing this by retaining and retraining current employees along side hiring more. The 2024 target is to sell between 1000 and 1500 EV motorcycles before the end of the year. Harley Davidson Live Wire is their current EV motorcycle which currently has three variants and is the bike targeted to be improved upon and increase sales. Harley Davidson plans to solely focus on EV bikes and believes it's the future of the brand.

The future is also focused on sustainability, improving technological integration and tapping into new demographics.

With plans to become carbon neutral by the year 2030 and massively reduce their carbon footprint by adopting green manufacturing practices (repurpose.global, n.d.) in practices like

using renewable energy sources to power their factories and reducing waste. Harley Davidson looks to have a greener future ahead of them.

Live Wire started as a sub brand of Harley Davidson for the first production bike and has since been adopted under the Harley Davidson name signalling their commitment to the brand. For the year 2030 they intend on producing a catalogue of EV motorcycles ranging from entry level to premium offerings. A large amount of their grant and money they invest will be going into battery development to improve the range, charging times and battery life of their motorcycles and potentially collaborations with an EV charging brand to improve the infrastructure for electric charging, specifically across America.

When it comes to design Harley wants to maintain their distinctive and historic look, following it through into their EV range. Power will also remain a constant, with torque electric motors at the helm EV bikes will likely outperform their combustion engine predecessor in performance.

Some of the technological innovations they plan to implement into their bikes include real-time tracking, smart navigation, voice activation, and performance analytics. Further down the line autonomous riding and Ai assistance, which will increase safety and ease of use for the vehicle.

The demographic market Harley Davidson has been focused on is a narrow but loyal following on the brand since their first production bike, they now hope to broaden this market with the new EV range without losing their existing fan base. The current market is middle-aged men within the USA, the new market they target to sell towards includes women, Asia and European markets.

Harley Davidson have stated they will go an all-electric brand in the future, but this will be a long-term transition and not an overnight process, no date has been put on this yet. (Toll, 2023)

Concluding And Defining The Brief

This Harley Davidson hoverbike is a daring step into the future of urban transportation. The bike will give the user a new exiting, safe and efficient way to travel. Not only is it an improvement for generally transportation but its an environmentally friendly answer for unhealthy emissions and pollution problems growing cities face. The year 2030 will see this solution prevail, by combining state of the art technology with new sustainable engineering methods and the proven design language of Harley Davidson. With This vehicle I hope to improve the quality of life in urban environments by making mobility and commuting more efficient in every way possible.

This hoverbike will provide the Harley Davidson lifestyle to a wider audience and a new mode of transportation with its innovative and unique methods of elevated transportation.

Bibliography

1. evtol.news. (n.d.). *Hover Scorpion*. [online] Available at: <https://evtol.news/hoversurf-scorpion/>.
2. chris.malloy (n.d.). *LandingPage*. [online] Malloy Hoverbike. Available at: <https://www.hover-bike.com/>.
3. <https://www.facebook.com/adamgraycars> (2024). *Wild flying motorcycle transforms into a hoverbike*. [online] Supercar Blondie. Available at: <https://supercarblondie.com/la-moto-volante-lmv-496-flying-motorcycle/> [Accessed 15 Nov. 2024]
4. Stanzione, K. (2019). Aerospace engineering | Britannica. In: *Encyclopædia Britannica*. [online] Available at: <https://www.britannica.com/technology/aerospace-engineering>.
5. www.rohde-schwarz.com. (n.d.). *Vehicle-to-Everything*. [online] Available at: https://www.rohde-schwarz.com/uk/solutions/automotive-testing/automotive-connectivity-and-infotainment/vehicle-to-everything/connectivity-v2x_231776.html?mid=10884&midx=vehicle-to-everything_aut-connectivity-generic_search_text-ad_r-eu_&kw=cellular%20v2x [Accessed 15 Nov. 2024]
6. www.sciencedirect.com. (n.d.). *Ducted Fan - an overview* | ScienceDirect Topics. [online] Available at: <https://www.sciencedirect.com/topics/engineering/ducted-fan>.
7. Highlights of Local Law 97. (n.d.). Available at: https://www.nyc.gov/assets/nycaccelerator/downloads/pdf/ClimateMobilizationAct_Brief.pdf.
8. EASA. (n.d.). *What is UAM*. [online] Available at: <https://www.easa.europa.eu/en/what-is-uam>.
9. Civicmedia.us. (2024). *Harley-Davidson Revs Up Electric Future with \$89M Federal Grant*. [online] Available at: <https://civicmedia.us/news/2024/7/5/the-grant-will-enable-them-to-expand-the-facility-in-york-county-pa> [Accessed 15 Nov. 2024].
10. Harley-Davidson (2023). *Harley-Davidson - Our Strategy*. [online] investor.harley-davidson.com. Available at: <https://investor.harley-davidson.com/our-strategy/default.aspx>.
11. StateImpact Pennsylvania. (2024). *Harley-Davidson in York County gets \$89 million to boost E-motorcycle production* | StateImpact Pennsylvania. [online] Available at: <https://stateimpact.npr.org/pennsylvania/2024/07/24/harley-davidson-in-york-county-gets-89-million-to-boost-e-motorcycle-production/> [Accessed 15 Nov. 2024].
12. repurpose.global. (n.d.). *Green Manufacturing: The Business Benefits of Sustainability*. [online] Available at: <https://repurpose.global/blog/post/green-manufacturing-the-business-benefits-of-sustainability>.
13. Toll, M. (2023). *Harley Davidson CEO says the brand 'will be all-electric' in the future*. [online] Electrek. Available at: <https://electrek.co/2023/01/16/harley-davidson-electric-motorcycles-future/>.
14. Spike, D. (2023). *Redline Harley-Davidson®*. [online] Redlineharley.com. Available at: <https://www.redlineharley.com/blog/what-is-the-difference-between-a-hardtail-and-softail--55891> [Accessed 15 Nov. 2024].
15. New York City Tourism + Conventions. (n.d.). *Flatiron Building*. [online] Available at: <https://www.nyctourism.com/attractions-tours/flatiron-building/>.
16. Vargas, M. (2024). *Harley Davidson Logo: Meaning, History, Design Influences, and Evolution - Boon : Best Logo Maker for Your Needs*. [online] Boon : Best Logo Maker for Your Needs - Create professional logos instantly with Boon. Elevate your business

- identity in minutes. Available at: <https://blog.boon.so/harley-davidson/> [Accessed 15 Nov. 2024].
17. Tesla (2024). *We, Robot* | *Tesla*. [online] Tesla. Available at: <https://www.tesla.com/we-robot>.
 18. Mobileye.com. (2024). *The Most Advanced Collision Avoidance System* | *Mobileye UK*. [online] Available at: <https://ims.mobileye.com/fleets/uk/technology/> [Accessed 15 Nov. 2024].
 19. Orscheln Products. (2022). *Redundant Aircraft Systems*. [online] Available at: <https://orschelnproducts.com/redundant-aircraft-systems/>.
 20. ntrs.nasa.gov. (n.d.). *Chapter 2: Aerospace Materials Characteristics*. [online] Available at: <https://ntrs.nasa.gov/api/citations/20180001137/downloads/20180001137.pdf> [Accessed 15 Nov. 2024].
 21. www.bppulse.co.uk. (n.d.). *Electric Car Charging Time: What You Need To Know* | *bp pulse*. [online] Available at: <https://www.bppulse.co.uk/going-electric/how-long-does-it-take-to-charge-an-ev>.