HERMES

"ANALYSIS OF THE POTENTIAL AND PREDICTION OF FUTURE SOLUTIONS
IN THE AREA OF PERSONAL MICRO AVIATION
WITH A TIME HORIZON OF 2030."

Johannes **SMOLLE**

A COOPERATION BETWEEN

FH JOANNEUM || **UC BERKELEY**

MADE POSSIBLE BY:

THE AUSTRIAN MARSHALL PLAN FOUNDATION

Industrial Design Research Paper by:

Johannes **SMOLLE**

Supervised by:

Dipl. Des.(FH) Johannes **SCHERR** Susan **GIESECKE**, MA

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0 ABSTRACT

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// HERMES

Social development of urbanization with densely populated megacities developing in the near future and environmental challenges necessitate new concepts for individualized non-autonomous transportation that still leaves room for exploration and curiosity. Looking both into the past and into the future I tried to develop a new concept of airborne individualized transport based on the biomechanical aspects of the hummingbird´s flight. Mankind´s ancient dream to take flight has long come true. Yet planes, helicopters and even the recently developed drones are unsuitable for individualized use in densely populated places. Apart from the problem of emissions they require too much space for take-off or landing, are unable to perform nimble maneuvers and generate noise, which makes their use above populated streets impossible. I studied historical and present concepts of flight machines as well as new solutions for power generation, actuation and data processing available now or feasible in the near future. Based on this research and the subsequent insights, I designed "Hermes", an individualized, "motorbike-like" ornithopter solution for an unparalleled flying experience. The mainstays of this new concept are: A design mimicking the flying properties of a hummingbird, which allows for nimble and quick maneuvers into all directions while requiring minimum space for take-off and landing. H.A.S.E.L (hydraulically amplified self-healing electrostatic actuator), a pump-free system consisting of electrically insulated pockets filled with an oil like liquid that can change size and shape when put under voltage for actuating the wings. A hydrogen power plant with a P.E.M. fuel cell (proton-exchange-membrane cell) which provides the required power in an ecologically compatible way without generating relevant noise. A passive flight assistance system processing continuous flight data generated by sensors, ensuring safety for the pilot. Wearable immersive augmented reality (W.I.A.R.) glasses enabling the pilot to get real-time information about relevant flight parameters. All technical components are in part already available, in part they exist as prototypes or are in the state of promising development, indicating towards a possible feasibility in 2030.

INTRO 0

01

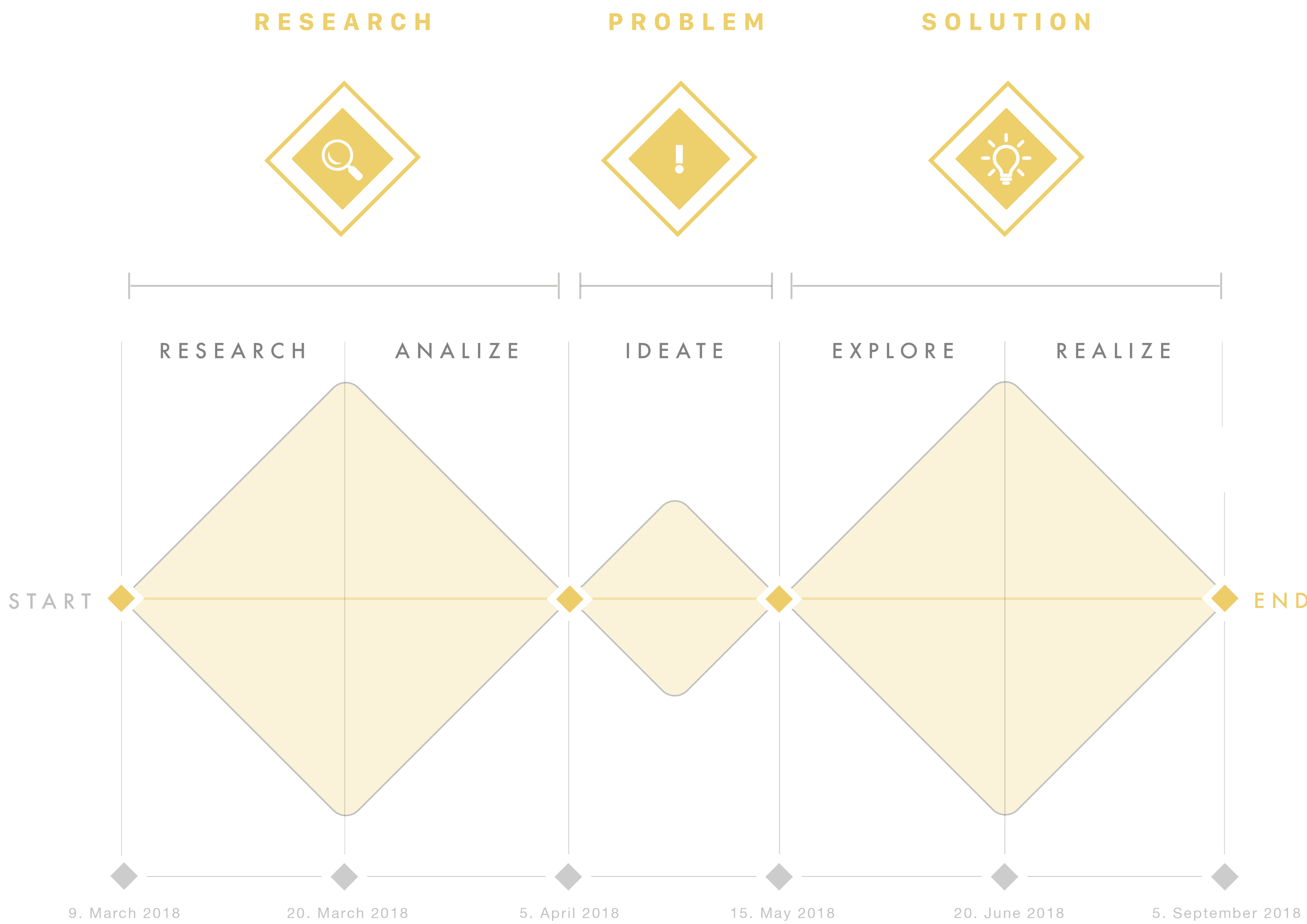
// PERSONAL MICRO AVIATION

The term "personal aviation" has existed for almost a century, referring to flight solutions accessible to trained pilots and hobbyists. At a more granular level, "micro aviation" indicates air mobility systems that enable one pilot to fly self-sufficiently. Notable examples include wingsuit flying and hang gliding. "Personal micro aviation" therefore combines the benefit of easily accessible one-seat aircrafts with highest quality ergonomic standards.

02

// METHODOLOGY

The research paper as well as the project are structured according to the „Double Diamound Innovation" process. Findings and products of the research phase can be found in the first third of this paper. The problem statement is rendered by analyzing those insights and can be found in the middle section of the paper. Ideation and orientation processes that ignited the core idea as well as an indepth description of the final solution are subject to the last part of this industrial design research paper.



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1 HISTORY OF FLIGHT

01

// PEGASUS

The first metaphorical depiction of mankind's desire to roam the skies was expressed through one of the most famous mythological creatures; Pegasus, the winged stallion. Captured by the Greek hero Bellerophon with the help of Poseidon and Athena, Pegasus greatly aided the battle against the monstrous Chimera. Later, to reward for its long and faithful service as an assistant to the gods, Zeus transformed the stallion into a constellation of stars, now found in the northern sky. It´s striking appearance and heroic deeds echoed through centuries and inspired generations of painters, poets and craftsmen. Even during World War II a silhouetted depiction of Bellerophon, mounted on the great winged stallion was used as the upper sleeve insignia of airborne paratroopers of the Royal Air Force.[1]

02

// ICARUS

Alike Pegasus, the theme of Daedalus and Icarus counts as one of the most popular and quoted Greek legends: Daedalus, Father to Icarus and a very talented craftsman, built the labyrinth of King Minos to imprison a legendary half-man half-bull creature called the Minotaur. After falling into disgrace for helping Minos's foes to kill that very creature, father and son try to escape from Crete. To aid their highly risky undertaking, Daedalus fashions two pairs of wings out of feathers and wax. Before taking off, Icarus is warned of never flying too high nor too low for the sun would melt the wax and the dampness of the sea would clog his wings. Carried away by the awe and power of flight, Icarus's hybris eventually guides him to close to the sun, leading to his tragic fall and drowning in the sea. Despite leaving an early and powerful comment on the relationship between technology and man, the myth sparked immortal inspiration for Literature and Arts, as well as the idiom „don't fly too close to the sun".[2]

03

// DA VINCI

Leonardo da Vinci, born into the vibrant and progressive Renaissance, is not only famous as a great painter but also as a universal genius who studied and pioneered numerous fields such as medicine, engineering and biomimetics. His manuscripts and codices indicate first systematic and profoundly elaborated inventions of flying solutions. Studying the flight of airborne animals such as dragonflies, doves and eagles, he eventually created and tested ideas like the "Aerial Screw", which is generally considered as the precursor of modern helicopters. This project is deemed interesting not merely for the mechanical solution but for Leonardo´s unique perception of air described as a "thinner than water dynamic fluid" that a machine could twist or screw itself into. Further serious attempts at conquering the skies are apparent by a flying machine that relies on muscle power as an energy source and flapping motions to create lift. After testing the limits of muscle power in a stable environment he even simplified his concepts towards a rigid gliding solution rather than a dynamic flapping one, for he correctly proved man powered propulsion to be insufficient in his scenarios.[3]

04

// MONTGOLFIER

Joseph-Michel Montgolfier and Jacques-Étienne Montgolfier were born into a family of paper manufactures in the north of France. While Joseph was seen as the dreamer and maverick of the family, his brother Jacques went on to pursue his talents for construction by studying architecture in Paris. Endowed with an intrinsic obsession with aeronautics it was Joseph, who built parachutes and other flying devices. He happened to make an outstanding observation: One day he witnessed clothes billowing and lifting upwards while they were drying over open fire. Intrigued by the effect, he started contemplating the construction of flying machines incorporating the observed levitation. After years of development and testing involving his brother Jacques and close friends the brothers Montgolfier were able to demonstrate publicly the first flight of a hot air ballon in the summer of 1783 in Annonay. After having witnessed animals aboard the first successful ballon flights the King of France allowed piloted attempts shortly after, culminating in the first free flight by humans in history, in autumn of 1783.[4]

05

// LILIENTHAL

Often called the „Father of Flight", Otto Lilienthal was a German engineer who pioneered the invention of heavier-than-air flying solutions. His contribution to aviation consists of the concept of air-flow and ascending force based on disciplined research of the white stork flight. He carried out over 2,000 well-documented flights starting as early as 1891. His gliders that were worn on the pilot´s shoulders featured sufficiently wide wing-spread and aerodynamic properties to carry Lilienthal over distances as long as 250 meters. During his career he developed a dozen models of monoplanes, wing flapping aircrafts and even two biplanes. He constantly struggled with the tendency of his designs to pitch down, which made the aircraft hard to manoeuver. Part of this problem was the fact that the amount of weight shift was limited by the attachment of the glider on the shoulders. During one of his attempts, Lilienthal´s glider pitched forward again and headed down hopelessly. The following crash from a height of 15 meters lead to severe spinal injuries from which Lilienthal succumbed 36 hours later. His research and experiments paved the way for many ultra-light aircrafts such as the modern hang glider. He is widely perceived as the most important contributor to the field of aeronautics in the 19th century.[5]

06

// WRIGHT

Orville and Wilbur Wright were two American engineers, inventors and aviators, credited with the creation of the first successful airplane. They tackled one of the biggest problems of aviation at that time, the maintenance of an aircraft's equilibrium, through their breakthrough invention of the three-axis control system. Inspired by the stories of dedicated pioneers such as George Cayley and Otto Lilienthal, they utilized their knowledge and mechanical skills to construct the first airplane. Rather than starting with the development of stronger engines to power their aircraft, as did other contemporary aeronauts, they focused on creating a reliable method of aircraft control. After they pinned down the perfect shape for their glider through data gathered in their own small wind tunnel, they constructed a 12 horsepower engine to power their flight. Finally, on December 17, 1903 their aircraft took off, and covered a distance of 37m in 12 seconds marking the first successful powered flight of history. All powered aircrafts developed up to this time rely on the foundations laid by the Wright brothers on that very day.[6]

2 THEORY OF FLIGHT

01

// LIGHTER-THAN-AIR

The breakthrough discovery that fuelled the first free flight in history was the concept of „buoyancy". This effect, also referred as „uplift", describes the tendency of objects to rise within a medium the density of which is higher than their own. During the floatation of cork in water or the uplifting of clothes dried over fire, buoyancy is visible. The hot air balloon, the first buoyant aircraft, became possible when the Montgolfier brothers capitalized on the fact that heated air is lighter than cool one and thus were able to lift a container filled with it. As research got more sophisticated, scientist discovered that certain gases, for example helium and hydrogen, are also less dense than air. More than a century after the first hot air balloon took flight, Ferdinand von Zeppelin's hydrogen inflated aircraft solved the hitherto biggest problem of balloon transportation, the lacking controllability. Equipped with rotors and a rudder, these passenger balloons were able to navigate with high precision. Those so called „Zeppelins" featured great comfort through elaborate gondolas incorporating even dining rooms. Yet the Hindenburg catastrophe at Lakehurst when the flammable Hydrogen exploded and the Zeppelin caught fire caused a defeating backlash for mass balloon transportation. Despite necessary improvements like the usage of non- flammable gases such as helium, hot air balloons never really recovered their popularity as a mainstream transportation vehicle.[7]

02

// HEAVIER-THAN-AIR

Like lighter-than-air flight, all heavier-than-air flying machines rely on basic physical forces. Birds are able to cover very long distances not only by flapping their wings but also by harnessing the lift of their wings special shape. All flying animals must carefully balance lift, drag, weight and thrust, and that is what all airplanes have to do as well; thrust must exceed drag and weight ought to be balanced by lift. The airfoils of fixed wing aircrafts for example are shaped according to observations in nature, resembling wings that promote flight by letting air flow faster on their top than on their bottom. The resulting difference in air pressure (greater on bottom) spawns the force of lift.[8] More than in buoyant aircrafts, the development of heavier-than-air flying solutions greatly relies on intensive studies of animal flight. If it was not for Leonardo da Vinci's sharp eye, the bravery of Lilienthal´s experiments or the innovative wind tunnel of the Wright brothers, the first powered flight may have taken place much later. Today the variety of heavier-than-air craft covers a wide range from non-powered gliders and kites, to powered airplanes, rotorcrafts and ornithopters. Every categorized solution successfully battles the constraints of nature with the newest inventions and developments of technology to enable flight.[9]

03

// GLIDER

Compared to powered airplanes, gliders only feature three forces acting on them. Lift weight and drag, are balanced in these flying systems for they lack a source of thrust like the engine of a motorized aircraft. Stripped down to the most necessary parts, hang-gliders are a great example of perfect weight reduction. The minimal overall structure ensures safety and support while being only covered with fabric where the airfoils are shaped. The control is also uttermost reduced, just relying on gentle shifts of weight distribution caused by the motion of the pilot´s body relative to the glider. Because the hang-glider is not opposing drag by generating thrust, the glider descends in steady pace unless updrafts are present above the terrain: Because gliders trade potential energy, gained by starting from high ground, for velocity, long flight times can only be achieved by using additional energy. The thermal updraft generated by hot air pockets that form naturally on the terrain allows the glider to stay aloft and to regain altitude. While gliding concepts are very sensitive to their environment and may only be used under certain conditions, they still pose an impressive example of aerodynamic engineering and intelligent use of materials.[10]

04

// ORNITHOPTER

The word ornithopter is descriptive in itself, consisting of the Greek words for „wing“, and „bird“. The main difference between an ornithopter and other powered flying solutions is the generation of lift by imitating reciprocating motions of a bird’s wing rather than using rotating airfoils. While tackling the problem of human flight by trying to replicate flapping motions is an obvious approach, it poses still a though engineering challenge that is hardly solved in an economically interesting way up to this time. The history of flapping flight spans from the legend of Daedalus and Icarus to the first successful ornithopther based flight of Abbas Ibn Firnas in Spain around 875 AD. Although Leonardo da Vinci’s winged drafts gained a lot of attention throughout the centuries, it was only in the early 1940s when Adalbert Schmid first successfully flew a manned and powered ornithopter. Despite the challenges the development of an ornithopter involves, the device could potentially provide benefits like better manoeuverability, improved efficiency and noise reduction when compared with rotor-based solutions.[11]

3 AIRPLANE PACKAGE

01

// WINGS

The wings of an airplane generate most of the lift and must be propelled forward through the air in order to do so. They come in all shapes and sizes and are generally engineered towards optimizing their aerodynamic properties by reducing drag and promoting lift. The Slats wich are positioned on the leading edge of the wing enable the pilot to adjust the angle of attack, thus increasing the overall lift generated by the wing. At the trailing edge however the purpose of the Flap is to increase the chamber of the airfoil, which is useful to sustain lift even at lower speeds. The roll of the whole airplane is controlled by the asymmetrically actuated ailerons allowing the pilot to move the plane left or right during flight. [12]

02

// PROPULSION SYSTEM

In case of a typical propeller airplane the propulsion system consists of a piston engine that is optimized for aviation but largely features the same characteristics as a car engine and the airfoil shaped blades fitted to generate the thrusting forces. Jet Engines are another widely adopted propulsion method. They produce thrust by releasing compressed air through a directed nozzle or pipe. A combination of the above mentioned systems come in form of a TurboProp engine which is essentially a propeller driven by a jet engine.[13]

03

// EMPENNAGE

The rear part of an aircraft is called empennage. Consisting of the Rudder, Stabilizers and the Elevators its main function is flight control and the maintenance of an airplane's equilibrium. The horizontal stabilizers control the pitch and airspeed. Without this balancing device in place an airplane would eventually succumb to its tendency to pitch down and decrease airspeed. The Elevators are positioned at the rear of the stabilizers and enable the pilot to control the pitch. The same concept applies to the vertical axis and comes in form of the vertical stabilizers and the hinged surface rudder to control the yaw.[14]

04

// FUSELAGE

Describing the main structural component to connect and bridge the package necessities the fuselage holds the passengers, crew and cargo. A specific area of interest in the field of aviation has always been weight reduction and optimization of the fuselage. Commonly used types of structures are: Geodesic structures, Truss structures as well as Semi-monocoque and Monocoque shells. Geodesic structures for example are redundant interwoven meshes that are lightweight, strong and rigid and therefore able to survive localized damage without total failure.[15]

05

LANDING GEAR

Often consisting of wheels and struts the landing gears of airplanes have very obvious purposes. Although some more sophisticated aircrafts even feature floats or skis to land on all sorts of terrain, a single ending airplane will most certainly feature a conventional or tricycle landing gear. The conventional gear distributes weight over two main wheels in front and one under the empennage in the back. A tricyclic leading gear however consists of a nose wheel and two main wheels at the gravity center. To ensure better aerodynamic properties and reduction of drag most landing gear is also retractable upon lift-off.[16]

HUMMINGBIRD FLIGHT 4

01

// FEATURES

Hummingbirds count as one of the most extraordinary aviating species known in the animal kingdom. Featuring flight patterns that enable them to seamlessly and quickly shift from perfectly sustained hovering states into rapid acceleration, they are even capable of maintaining high manoeuverability at top speeds exceeding 15m/s (54km/h). Their insect like flapping rates vary from 12 beats per second in larger species of hummingbirds to almost 80 bps in the smallest breeds. Hummingbirds can also be seen when flying backwards on certain occasions. This extends their array of aeronautic capabilities to unparalleled degrees of freedom compared with other birds or insects. Their rapid wing beating is enabled by the highest rate of metabolism among animals. The relative oxygen consumption of the muscle tissue during flight for example, exceeds an elite human athlete by 10 times.[17]

02

// AERODYNAMICS

Supporting intricate and energy intensive flight states such as hovering requires specialized motion patterns and muscosceletal systems. Hummingbirds have adopted insect like flying styles that can be achieved by a twist of their wrists which effectively inverts the wings when pushing them back and forth. This wing travel enabled through tiny twists of their humerus, marks a distinct contrast to the motion of birds who flap from the shoulder. This makes the biggest evolutionary innovation in their flapping motion possible: Rendering not only the upstroke of their wings aerodynamically invisible, which is what must birds do, but also aerodynamically effective, which may only be observed in certain insect species. Research hence indicates that 75% of total lift supporting a hummingbird´s weight is generated through the downstroke and 25% of lift during the upstroke while performing the famous „figure 8" motion. To overcome the risk of losing muscle power during their energy intensive flight, they converged on a simple but effective solution: They have relatively big muscles that contract fast but generate small motions, resulting in large amounts of transferred power.[18]

03

// ANATOMY

The major flight muscles of the hummingbird are the pectorals major, which pulls the wing performing the downstroke, and the supracoracoideus, which contracts to allow for the special upstroke. Accounting for 25% to almost 35% of a hummingbird´s total weight these two flight muscles are relativily heavier than in any other bird. As the bones of their wings are hollow, arranged in close proximity and short they are perfect for ease at rapid speeds and allow for quick turns. [19] Visually and spatially processing such rapid speeds and intricate manoeuvers poses a big challenge. It can only be mastered by an exceptionally dense array of neurons in the brain region tasked to handle visual stimuli. As studies indicate, hummingbirds feature that very hypertrophic neuronal morphology in the respective brain part, believed to be key in their advanced aeronautic navigation and collision avoidance.[20]

5 FUTURE SOCIETY

01

// URBANIZATION

The process of Urbanization is primarily caused by industrialization and modernization creating large numbers of jobs attracting numerous of people to shift their residency from rural areas into cities.[21] Accordingly, hundred new megacities will arise until the year 2030, implying that 60% of the world's population is going to live in big cities. These cities will expand massively in size presenting major environmental and economic challenges. For example, transportation poses a big issue for more than 10 million people living in a relatively small space will have to get from A to B on a daily basis. Cities are required to come up with strategies on how to adjust to much larger populations than they are supporting in the present. Actually, family as well as having a strong relationship to people in the closer environment is what most communities favored in the last centuries. These societies were more self-sufficient and they had a lower demand for mobility. Today, this traditional way of thinking has shifted towards individualism – possibly as a result of humans being constantly connected to people all over the world through their smart phones. In addition to life-style, economical reasons made our life more "flexible" than ever resulting in an extremely high demand for flexible and quick transportation.[22]

02

// DAY IN 2030

Imagine it is July 4th in the year of 2030. You get gently woken up by the room steadily becoming lighter. You open your eyes and see the playful shadow of leaves, which the wind just breathed on, projected onto your bedroom wall. As you start to fully awake your ears pick up the tender sound of birdsong in the background making you feel joyful and ready to start the day. Thanks to your smart home unit [23] this soon became a daily luxury. Refreshed you walk into your bathroom, as your mirror welcomes you with your up to date vital parameters, as well as with your nutritional status, which it has recorded with the help of the sensors in your toilet. You put your autonomous hands-free toothbrush in your mouth and go to your dresser to get dressed. As you walk into your kitchen the light smoothly adjusts to your favourite mode as you pass by, letting you feel as comfortable as possible. Based on your nutritional needs the kitchen counter suggests a few breakfast recipes, of course depending on the type of groceries delivered into your fridge system. After a delicious breakfast, you press a button on your phone for the autonomous car [24] to wait in front of your door. On the way to work, you finish up the presentation you have to make this afternoon and you order a few groceries which are delivered to you by a drone delivery service[25] while you are at work. A day in the year of 2030 will be dominated by autonomy enabling humans to live an easier life.

FUTURE TRANSPORT 6

01

// E-HANG 184 AAV

E-Hang is one of few intelligent aerial vehicles under development with the objective to make autonomous one person flight possible. Founded in China the approach of E -Hang follows the vision to „Let Humankind Fly Freely Like a Bird". [26] The electrical aerial vehicle claimed to function with a 100% green technology, provides a Medium-Short distance communication and transportation solution. This one passenger drone is capable of vertical takeoff and landing (VTOL) and can fly up to 130 kmh. Due to battery lifetime the drone is only able to stay aloft for 25 minutes but great developments in battery power are to be expected, hopefully leading to a longer flight duration. The number 184, depicts parameters of E-hang: 1 passenger, 8 propellers, 4 arms.[27]

02

// UBER ELEVATE

Following the original Uber concept (which matches any customer with a nearby driver to take him wherever he wants to go), Uber Elevate will offer the same service but for air transport and with autonomous aircrafts that are capable of vertical takeoff and landing (VTOL), with which customers can escape the daily traffic jams during their commute. Due to urbanization, commuting on ground solely would become impossible as well as increase the commuting time, which already is too long in certain cities. Uber Elevate proposes a solution, in which for example, a ride only takes 15 minutes while by car would it would at least take 2 hours and 15 minutes. The aircraft will manage take-off and landing within less than one minute and will enable for flight-speeds up to 330 kmh. One big obstacle Uber Elevate has to overcome is the noise issue for all rotor crafts tend to be extremely loud. One of the particular aerial vehicles alone would not emit too much noise pollution. However, considering the prospect of hundreds of these rotor driven aircrafts flying over a city, people in the streets would probably not be able to communicate properly. The sound waves from the rotors would be are reflected, multiplied and caught in between streets lined by sky-scrapers and other buildings.[28]

03

// HYPERLOOP

The idea of Hyperloop was first brought to life by Elon Musk, the intent of whom was to travel between cities in "no time". Hyperloop is a sort of train that runs in a loop which eliminates the parameters that usually slow down vehicles such as friction and air resistance. This makes the process silent, emission free and reduces journey time between big cities dramatically. Driving from San Francisco to Los Angeles by bus for example takes 8 hours, by train the journey takes four hours, and even with the airplane it will be three hours. However, with Hyperloop infrastructure it would take passengers only 30 minutes from San Francisco to Los Angeles making this invention the fastest way to cross the surface of the earth. Estimated numbers state that one capsule will fit up to 30 passengers. The system is designed to launch one capsule every forty seconds enabling more than 160,000 passenger transportations daily as well as 4,000 cargo shipments per day at a speed of 1,223 km/h. [29]

7 FUTURE TECHNOLOGY

01

// BATTERIES

Society nowadays gently embraces a clean energy future. Therefore, demands for efficient storing of power created through renewable energy types such as solar devices and wind increase drastically. As Electric Vehicles pose a corner stone of this movement, it is crucial to evolve them towards extended range and efficiency to ultimately penetrate mass markets and become mainstream. Both issues depict a driving force in the field of battery development and push towards an increase in energy density. The specific energy of the best Li-Ion batteries available today max out at about 250 Wh/kg, which is just 2% of gasoline's and 1% of hydrogen's energy density. In order to meet future demands batteries have to feature not only a high energy density but also a high specific power (W/kg; the amount of current supplied for a given use). Fast Charging and a long life in varying conditions are also properties required in order to achieve long- term feasibility in gasoline free transport solutions. Experts estimate that Lithium-Ion will pose the most promising technological base to bear the pressure of increasing demands in the future battery market. The promising 6-7% annual capacity increase forecast of Li-Ion batteries may be achieved through innovating on the anodes by incorporating silicon nanowires which could potentially provide 10 times higher energy density.[30] Besides li-ion the future may hold interesting new solutions such as the aluminum-air battery. Featuring a 10 times capacity increase as well, these promising Al-airs could deploy within the next 2-5 years.[31]

02

// P.E.M FUEL CELL

In the near future batteries will most likely fail to reach energy densities comparable to hydrogen. Many mobility concepts in the automotive industry pioneered the use of a physical hydrogen storage in combination with Proton-Exchange-Membrane Fuel Cells. The physical storage often materializes in form of a carbon-fiber-composite reinforced tank, that is able to store hydrogen under high pressures (500-700 bar).[32] The integral part of the system is the P.E.M Fuel Cell, than converts chemical potential energy directly into electrical energy. Its biggest advantage if compared to combustion engines is the avoidance of the „thermal bottleneck" (vast amounts energy being transformed into unusable heat). Another interesting feature of such systems are the positive ecological aspects of the direct emissions, which consist of water and just a little heat. Combining high efficiency (of 55%), high reliability (few moving parts) and eco-friendly emissions, hydrogen power systems will most likely have a lasting impact on the mobility industry.[33]

03

// H.A.S.E.L MUSCLE

Tasked to aid the future of more-humanlike robots a team of scientists developed H.A.S.E.L, a device that spawns movement and could have potential self-healing properties. H.A.S.E.L (hydraulically amplified self-healing electrostatic actuator) is a pump-free system consisting of electrically insulated pockets filled with an oil like liquid that can change size and shape when put under voltage. Controlled with only two wires the concept is easily implemented and versatile. The research published in „Science Robotics" in early 2018 documents a mechanism as strong as an elephant, as flexible as an octopus and as fast as a hummingbird. One of the three shapes presented in their research is made of liquid pouches covered in ionic conductors. The device is able to lift a gallon of water with ease. Coming at very low production costs with less than a dollar in small volume scenarios and low voltage operating levels the innovative concept of the H.A.S.E.L Muscle is perceived to have big potential impacts in the area of robotics and prosthetics, offering more „lifelike" solutions.[34]

04

// METALLIC MIRCOLATTICE

Consisting of a micro-struts-structure metallic microlattices provide greater stiffness, better energy absorption properties and a better strength-to-weight ratio than other cell based materials in comparable construction forms such as folded, foamed or honeycombed ones. Controlling parameters like relative density and stacking patterns are key to engineer these ultralight lattices towards certain application. As air pockets occupy a large portion of the volume (in some cases as much as 99% of the total volume) future use cases will target industries that thrive on high strength-to-weight ratios.[35]

05

// 4D PRINTING

Compared with 3D printing a process largely resulting in static structures out of basic materials, 4D printing is time-dependent and forges stimulus-responsive dynamic structures out of smart materials. Largely relying on effects of predictable reactive patterns between certain materials, possibilities arise to modify property, shape and functionality in the printed responsive system. Accurate mathematical modelling of the desired effect in the specific scenario is a preliminary step to every 4D printing design approach. By controlling water in a dynamic piece or by applying heat and focusing light on the reactive print, interesting mechanical behaviours have been achieved so far.[36]

06

// W.I.A.R

Research indicates that wearable immersive augmented reality could be a viable new technology to provide novel features and possibilities in safety-critical applications. The system provides potential to increase an operator´s performance, and ensures fewer losses of lives and general positive effects on operating conditions. W.I.A.R enables users to interact with a portable device that displays a digital layer of information atop a view of the physical world. The true power of the technology is rooted in a deep integration and responsive analysis of the surrounding physical environment. It will enable the user to prompt visual information in the process of correctly assessing situations thereby supporting decision-making. Systems like aviation, space, healthcare and transportation have been examined through pioneering projects in order to increase knowledge on how to avoid negative impacts on population, infrastructure and environment.[37]

8 NEEDS

01

// TRANSPORTATION

Key to all human progress is our inborn desire to explore. If humans had not found ways to move faster as well as to travel not only on land but also on water and in the air, we would not know anything about the moon, other cultures, lightbulbs or many other life changing inventions. In the beginning, we used animals for transport then there came boats, then cars, trains, and planes and many other ways to travel faster. [38] Nowadays, increase in speed is the core drive when thinking of vehicles in development. Everything has to happen right at the moment, we do not have time to wait. However, there are new challenges arising due to overcrowding in cities. How will the existing transportation solutions meet the needs of an ever growing population when they are failing to meet the needs of much fewer people today? Traffic jams, long metro lines, overcrowded walkways are already common problems. What will it look like when the number of population has tripled? When all these people need to commute? Some suggest that autonomy will be the only answer. Will we have to eliminate the human factor to travel safely in such close quarters? [39]

02

// HUMAN

True inner happiness, as the word “inner” already indicates comes from within. However, many other factors have to align for a human, enabling him or her to feel truly happy. The first to study contentment in humans and to investigate this phenomenon was Abraham Maslow, a psychologist who published the Hierarchy of Human Needs [40]. Maslow used a pyramid to visualize the importance as well as the order in which needs have to be addressed. Needs that are depicted in the lower parts of the pyramid have to be fulfilled before one can satisfy needs which are located in the top parts of the pyramid, as Maslow concluded. A person´s basic need, such as shelter, water, warmth, sleep and safety has to be satisfied for an individual to be able to work on psychological needs such as belongingness or the feeling of accomplishment. Yet only when social and basic needs are satisfied, only then, Maslow states, is a person able to work on self-fulfilment needs. Self-fulfilment is won when a person is able to achieve his or her full potential, seeking personal growth and peak experiences. Psychologists nowadays found out, that all these needs have to be satisfied on a daily basis for a human to feel truly happy. A person who grew up not being able to establish deep connections with other people, will claim that he or she feels better being alone. Scientists have found out that humans, who fail to satisfy one or more needs, seem to use a “natural” protective process. They believe that they are somehow special and need not address all their needs. Unfortunately, the truth is that they can never be the best of themselves if not getting out of denial and starting to do themselves good by satisfying all their needs.[41]

RESEARCH

PROBLEM

SOLUTION

1. EXPLORATION
2. URBANIZATION
3. NOISE

1 PROBLEM

01

// EXPLORATION

improvement of every aspect in their lives, to the point of human immortality [42]. Progress in its concept, indicates directional change towards a solution of higher quality [43]. Curiosity breeds exploration and exploration usually leads to advancement. We would not have made it this far if it was not for curiosity (and exploration). We explore because we are curious and because we are able to pick up, process and react flexibly to information we have perceived in our environment. But what happens to the human brain when in the prospective future most processes will be automated by reasons of assisting the human and making our lives a lot easier, safer and better? A hypothetical day in a life in the year of 2030, described in the chapter „future society", is dominated by autonomy [44]. Everything humans do on a daily basis will be accompanied by assisting technology, talking to us, advising us, driving us, even feeding us. However, what remains of the extremely high developed and competent human beings, the ones who were used to do all these things by themselves? To predict the social changes an autonomous world could bring about, one could look at the social impact of smart phones, our everyday technical assistance. The way we have changed to interact and to live our lives has changed tremendously. Studies show that the constant usage of smart phones has reduced the quality and amount of face to face interactions [45]. We grow more and more insecure about our lives because social media are painting a picture of "unreachable" ideals.

02

// URBANIZATION

A rapid demographic shift in many regions of the world, where people living in rural areas move into cities, drawn by the chance of a better paid job, will be the cause of a hundred new megacities arising until the year of 2030. This extensive urbanization leads to a large number of challenges that need to be solved to ensure the quality of live. Heavy traffic caused by too many people living penned up, will pollute the air excessively [46]. The social situation will be strained by people being annoyed of having to sit through long traffic jams during their commute or by walking on packed sidewalks making their way to work or to lunch, there again waiting in a crowded restaurant to make their order. Cities like Mexico City, Sao Paolo or many cities in China or India are already heavily affected. The quality of live has decreased to a very low point. For such masses of people, traveling on the ground only will not be enough. City counselors will have to find creative ways of how to manage transportation. The only room that is left for people to be spread is the z-axis, meaning that solutions offering vertical transportation such as skyscraper hopping or hovering motorbikes are no longer futuristic phantasms.

03

// NOISE

Experiencing urban bustle can be something overwhelmingly beautiful, especially when traveling and diving into a totally new culture. Though some cities turn out to be different from what expected, tourists are sometimes shocked when for example they travel to a city like Mumbai or Peking, places that are immensely busy, smelly and loud. Millions of people with the need to get from A to B on a daily basis, using the transportation solution accessible to them nowadays create a lot of noise. Developers are already working on automated cars, which could drastically reduce the noise and air pollution. Solutions for automated flying vehicles are also in the developing process. Concepts of automated air vehicles which are described in the „Future Society" chapter use rotors to stay in air just like drones do. However, in order to carry passengers these vehicles have to be 10 times the size of a drone. The concept in itself sounds promising and convenient, but a NASA study [47] just found out that humans find the noise of drones even more annoying than the sound of cars. What is more, the sound of drones is piercing and even in higher altitudes, it almost made no difference to the annoyance level. Though they are an exciting development, drones already have been banned form many places by law because of disturbance [48]. This result means that automated flying vehicles based on rotor propulsion will likely face heavy opposition to the extreme noise they make.

AUTONOMY COMPROMISES

EXPLORATION

COMPROMISES TRANSPORT

URBANIZATION

COMPROMISES IMPLEMENTATION

NOISE

RESEARCH

PROBLEM

SOLUTION

1 BRIEFING

01

// EMOTIONAL

On an emotional level "Hermes" should be perceived as empowering, innovative and freeing. There should be a slight undertone which expresses the solutions as not just a technical machine but also something being „alive" and inspired by nature. The sense of awe that often accompanies stories and mythology of humans conquering the skies should be present in the emotional experience of "Hermes".

02

// FUNCTIONAL

High accessibility, safety and ease of use should be main driving factors of the functional design. A comfortable yet aerodynamically invisible resting position of the pilot, as well as a joystick interface that is understandable and easy to use are also integral to the "Hermes" functionality.

03

// TECHNICAL

Feasible aerodynamics, tangible mechanical solutions as well as a sufficient, ecologically compatible energy source are technical standards for any future aircraft. Additionally, the solution should focus on noise reduction wherever possible to ensure an adoptable design even in densely populated areas.

04

// AESTHETIC

The appearance of the "Hermes" solutions should first and foremost display innovation and underline the approach inspired by nature. By visually exposing functional elements, the perceived feasibility of the design can be obtained. Reduced complexity should be a driving force behind the main aesthetic design decisions. As a result, the structure of the solution can be easily recognized.

FUNCTIONAL

ACCESSIBLE
SAFE
EASY TO USE

EMOTIONAL

EMPOWERING
INNOVATIVE
FREEING

TECHNICAL

AERODYNAMIC
EFFICIENT
NOISELESS

BOLD
INNOVATIVE
BIOMIMETIC

AESTHETIC

2 DESIGN

01

// DRONE

When thinking about how a futuristic one-person flying solution could work, drones came to my mind for nowadays they are a common concept when it comes to personal aviation. Doing research I even found drones designed to fly humans. Yet something was bothering me and first I just could not put my finger on it. Elaborating on my research and stumbling onto beautifully designed motorbikes I found the problem. Drones look too much as if they were not from this world, not at all fitting in to the beauty of nature. And there is the noise already disturbing inhabitants. That was why I took a different approach and started to look into nature for a model that would inspire me to design what I was dreaming about.

02

// MOTORBIKE

Inspired by the abundance of form, function as well as the high potential for an adrenaline rush, I started to dig deep into the world of motorbikes. I saw the most futuristic ideas as well as classical bikes that have been big hits for ages. I discovered how the diversity of materials combined with extravagant structures may result in the character of motorbike design and in addition, divergent driving experiences. Nevertheless, whatever type one chooses, everything feels intense when riding a bike, which is yielding excitement, deep appreciation, and respect for the raw power of a machine between ones legs.

03

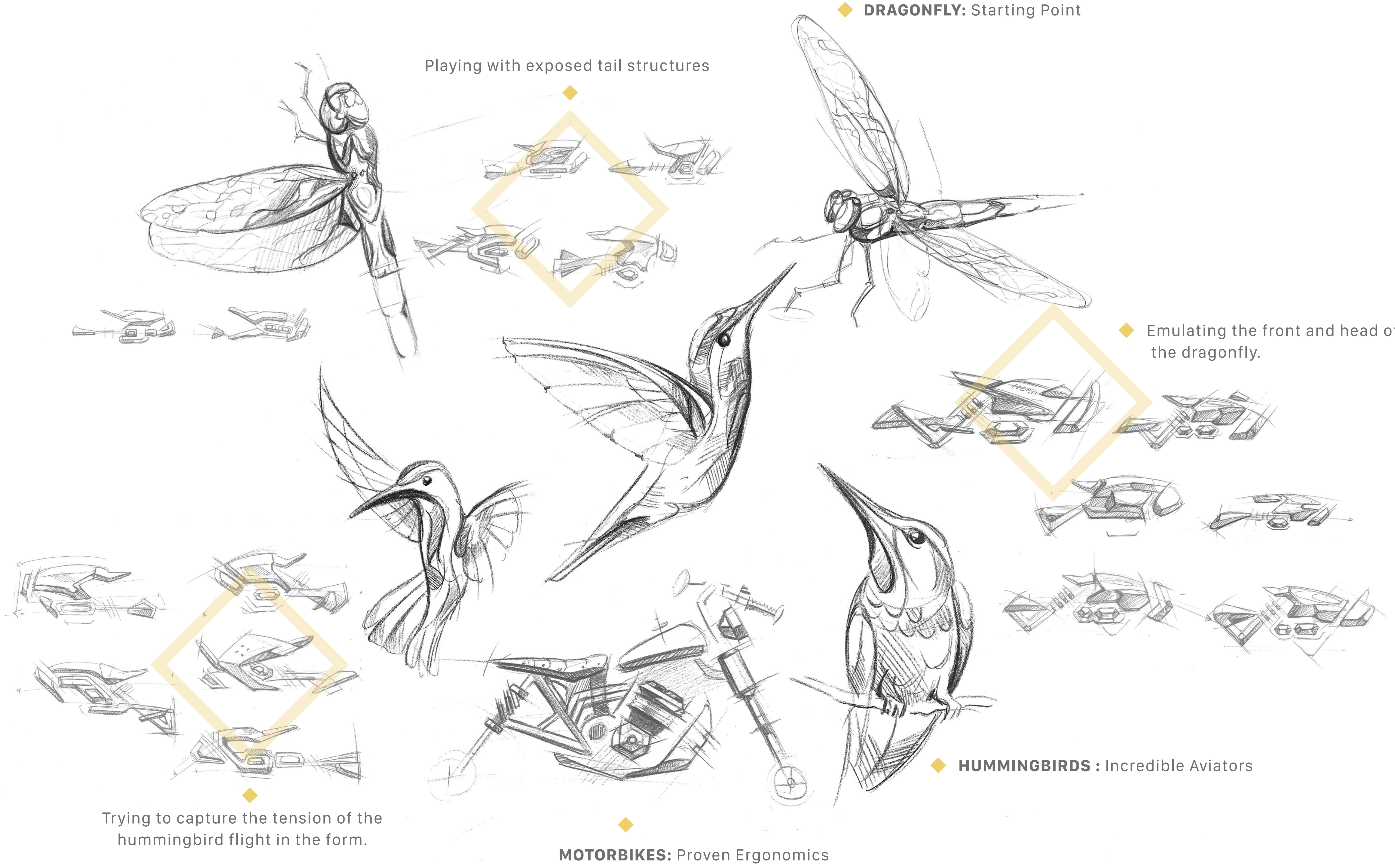
// DRAGONFLY

I was fascinated by the dragon flight for it represents one of the oldest and most primitive forms of insect flight. These small insects readily capture one's attention as they fly past, for they are large, colorful and strange looking. Yet learning more about the dragon fly flight I found that flying with two pairs of wings could pose aerodynamic challenges when wanting to build something similar. Moreover, the big wings would take a lot of space when in idle position. I decided to keep looking for a better fitting model.

04

// HUMMINGBIRD

Almost noiseless, but with the highest rate of motion known in birds the hummingbird buoyantly passes by on its way to find the sweet nectar which is fuel to it's extraordinarily biological system. Flying quick in one second tactically maneuvering around obstacles and in the other second seemingly standing still in air, drinking nectar out of a flower. Besides the phenomenal quick stop and go flight, the hummingbird strikes with its beauty, its colorful feathering - a great joy to all of its observers not to mention myself who was amazed when learning more about the hummingbird. Quickly I was convinced that it could not be any other bird I wanted to base my design on.

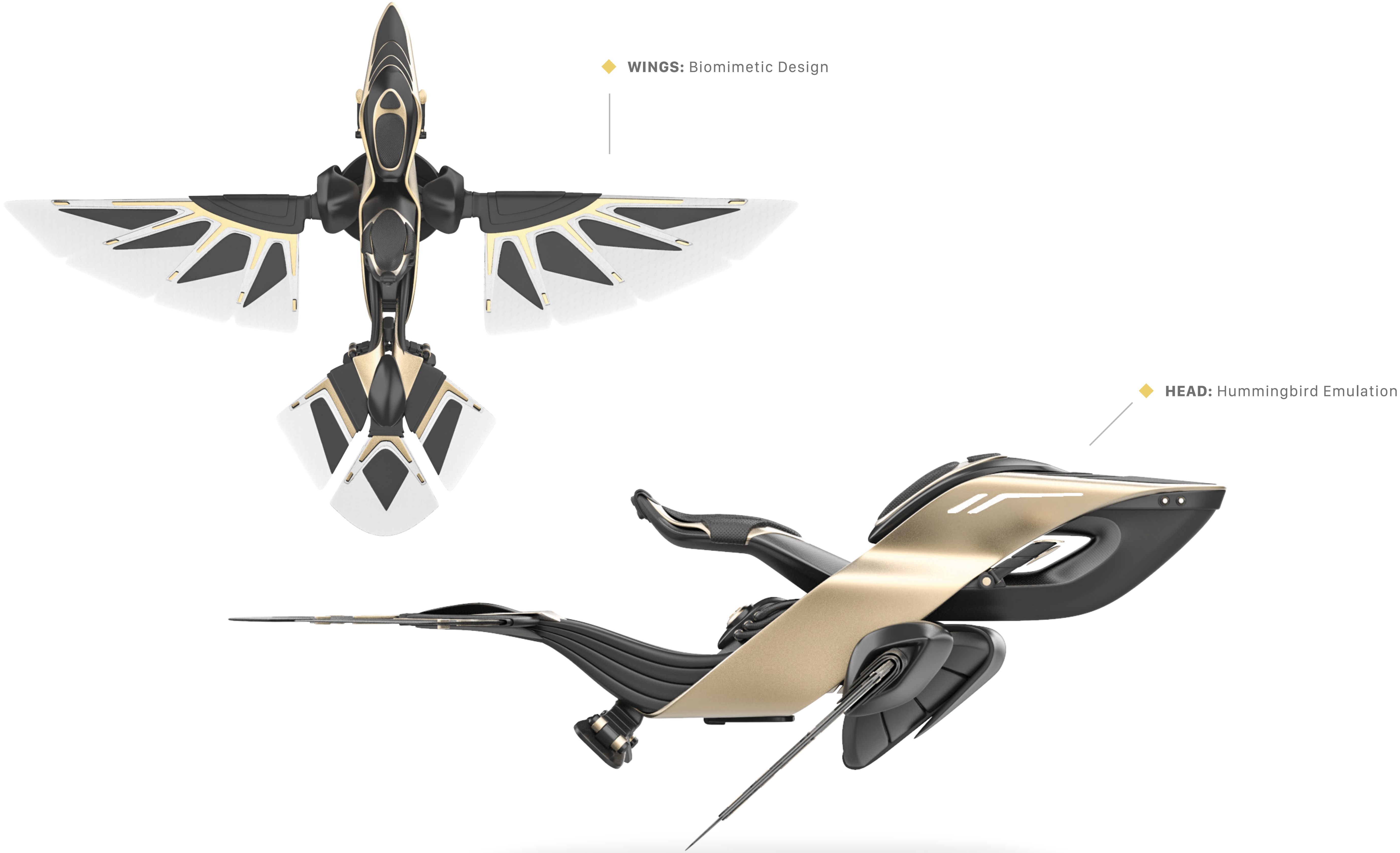

DRAGONFLY: Starting Point
Playing with exposed tail structures
Emulating the front and head of the dragonfly.
HUMMINGBIRDS : Incredible Aviators
Trying to capture the tension of the hummingbird flight in the form.
MOTORBIKES: Proven Ergonomics

3 OVERVIEW

01

// DESIGN

The overall appearance of the „Hermes“ is designed to be biomimetic with notable emulation of the hummingbird as a main inspiration. The potential pilot witnessing the aircraft for the first time should be attracted by the interesting nature inspired form, while still being comforted by recogniseable motorbike elements. The signature ribbon is made of anodized aluminum and is 3D-printed to feature lightweight material properties through an internal microlattice structure.


WINGS: Biomimetic Design
HEAD: Hummingbird Emulation

4 AERODYNAMICS

01

// BODY

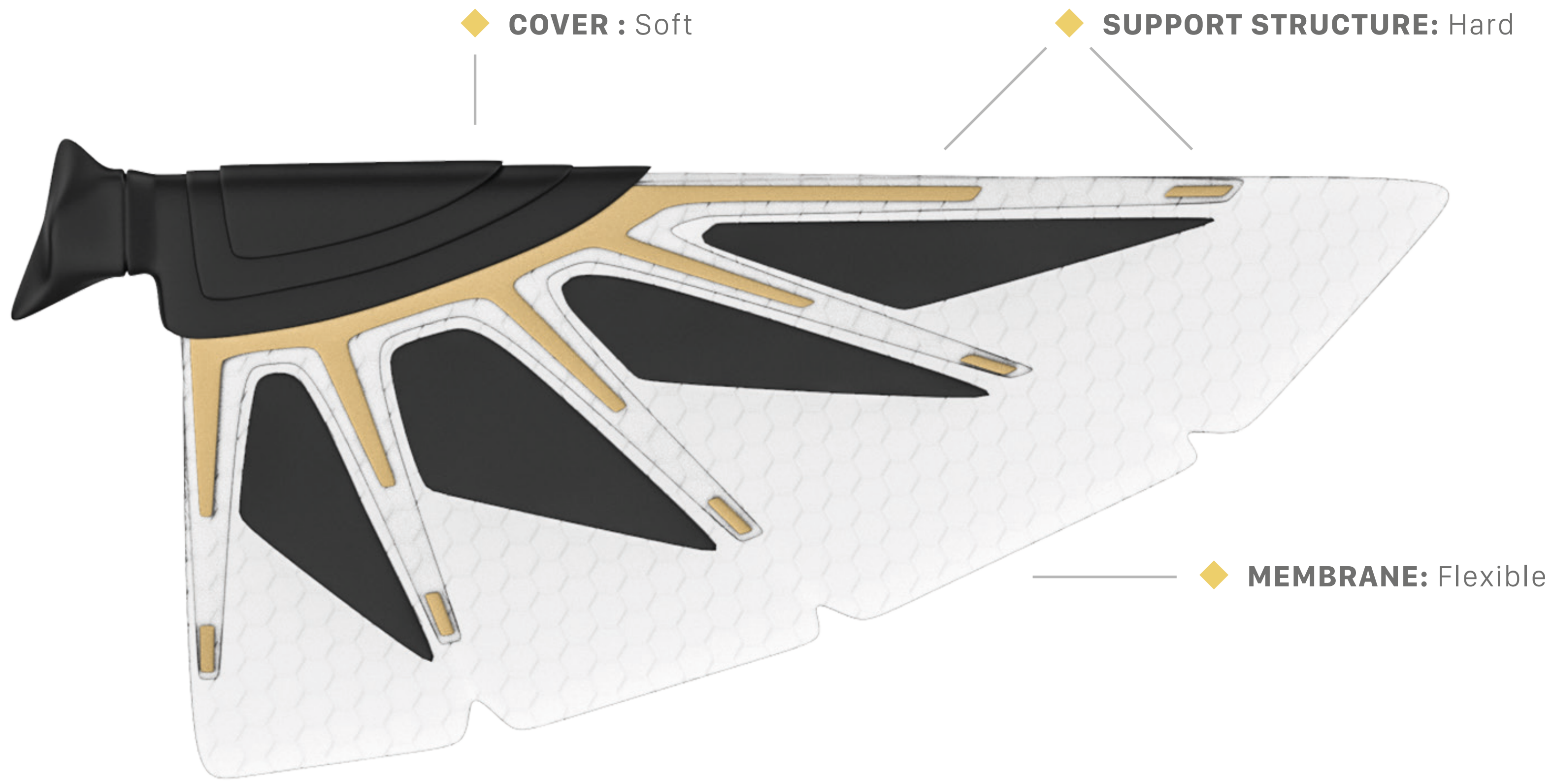
The main frame of the solution is optimized and streamlined towards drag reduction and optimal airflow. During forward flight the air is smoothly parted on the front end of the main frame (the structure supporting the head and the seat) by utilizing its bow like curvature. Drag is furthermore reduced by shielding the joystick interface with additional aerodynamically active surfaces. The main muscle system tasked with actuating the wings is angled forward to direct airflow along the sternum and to generate slight lifting forces during faster speeds. The rear part of the solution features the tail structure and muscles which are shaped to channel airflow to the tail feathers enabling their crucial functions as control and balancing devices during flight. The average coefficient of drag (Average Cd) of the body with the wings but without the pilot amounts to 0.58, which is comparable to the ACd of sport motorbikes.

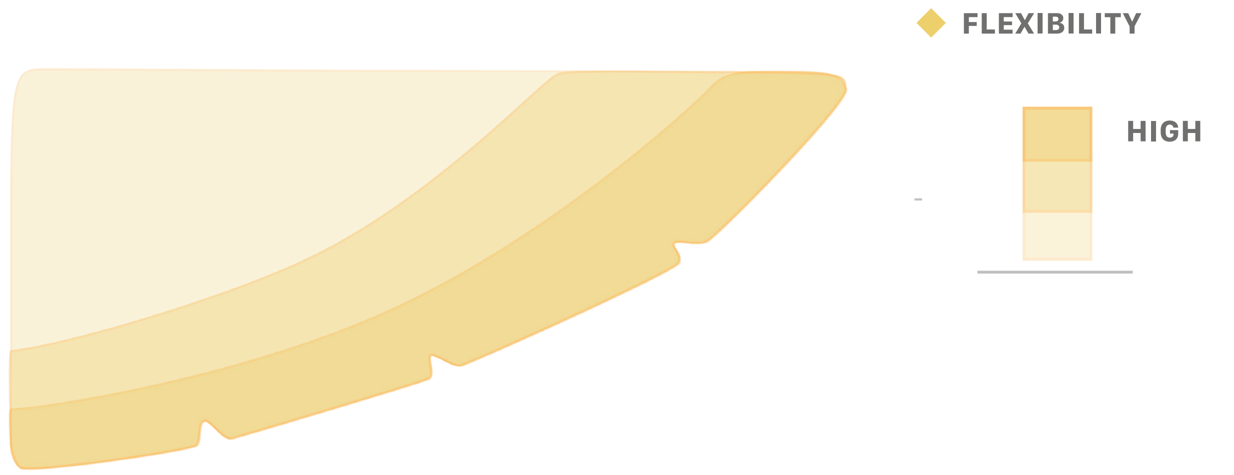
FIG. 1 // PRESSURE DIAGRAM

02

// WINGS

Acting as propulsion system during take-off as well as main lift-generating surfaces during gliding flight, the wings of the "Hermes" solution are the central part in the flying system. To ensure reliable function the wings are designed to be sturdy and stiff at the base. Visually and aerodynamically emulating the wings and feather of a hummingbird, the structure is lightweight as well as flexible at the leading edge of the feathers. The gradual transition between stiff structure at the base to flexible membrane at the leading edge results in material inertia capable of storing kinetic energy which greatly improves efficiency during flapping flight.[49]

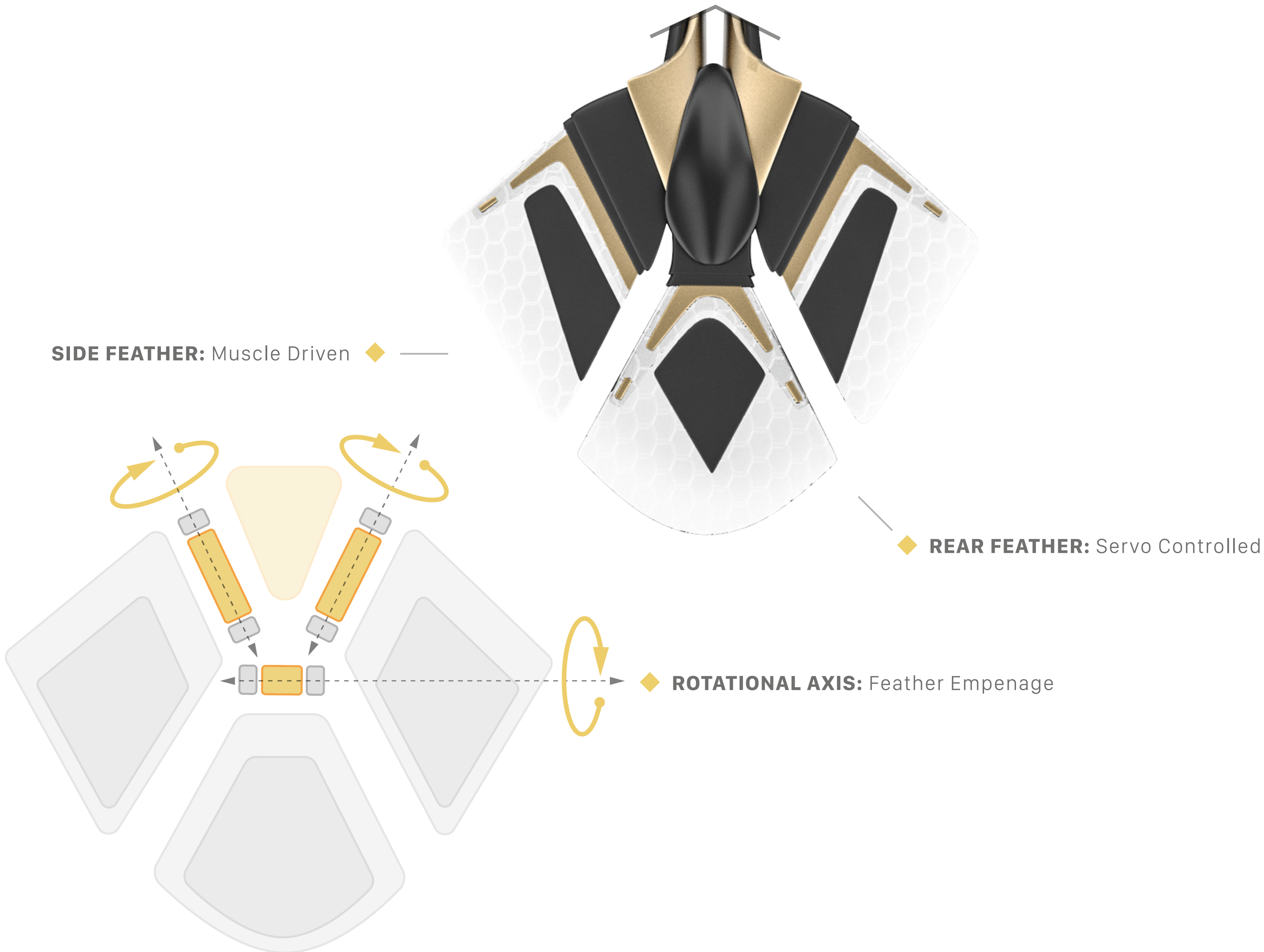




03

// TAIL FEATHERS

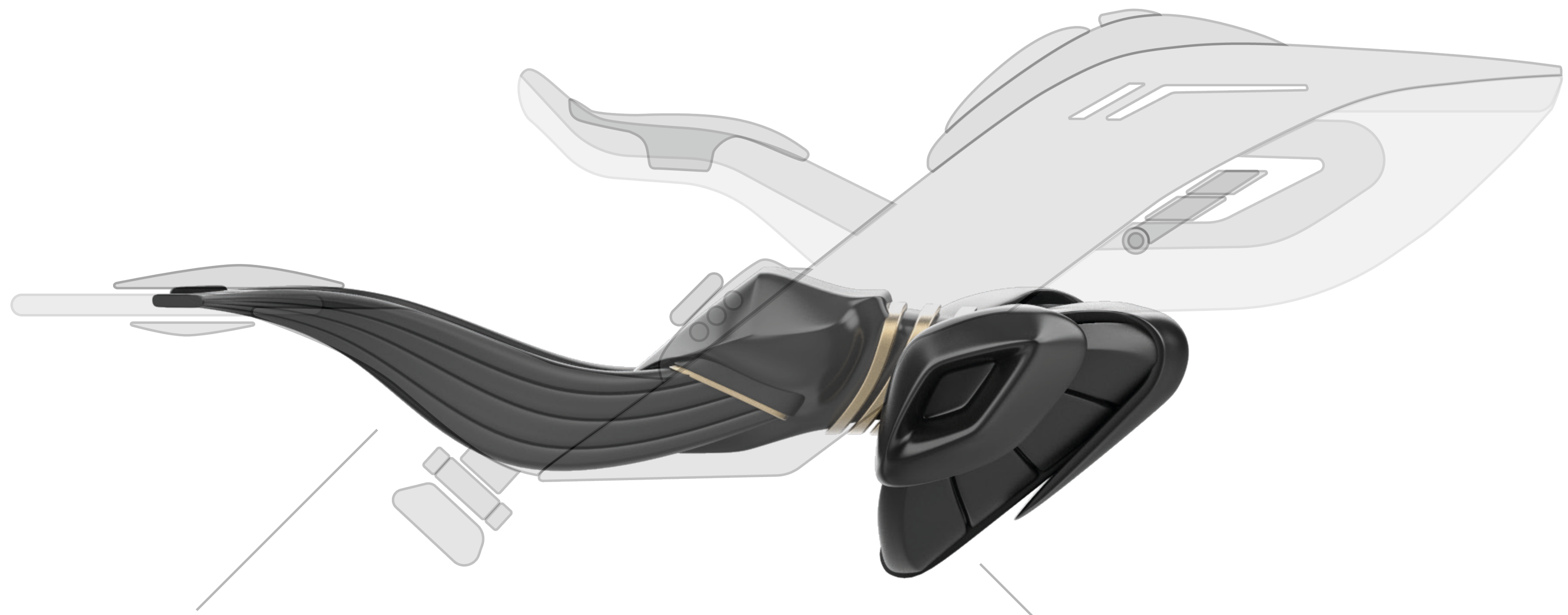
Controlling pitch, yaw and roll the tail feather´s functional tasks are comparable to those of an aircraft´s empennage. The rear feather is actuated by servos, which allow for precise movements at low speed and acceleration while the side feathers are able to perform rapid flapping motions through a muscle system comparable to the main wings. The flapping of the side feathers generates additional lift and thrust during take off and flying. This is necessary to counteract pitching. The tail feathers also add to the main benefits of a hummingbird-like "ornithopter" flying solution: complex flight maneuvers, high gust and wind resistance as well as balanced hovering.

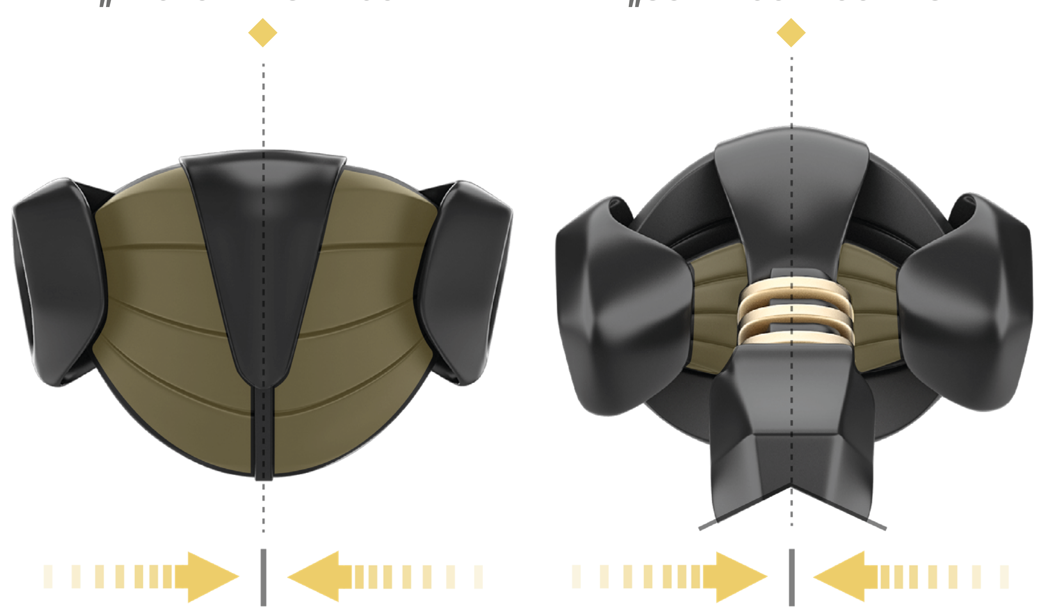


04

// MUSCLE SYSTEM

While the decision to actuate the wings through motors and circular motions would be obvious, further development of the H.A.S.E.L muscles could make more efficient and interesting solutions possible. Closely resembling and mimicking the musculoskeletal system of a hummingbird the "Hermes" flight muscle system features a large muscle to power downstroke, similar to the „pectoralis-major" muscle as well as a smaller one, the „supracoracoideus" muscle, to perform the upstroke. The system is framed by a „sternum" like structure and a middle bone supporting the joints at the end which connect to the wings. The efficient size to motion ratio of the hummingbirds muscles is also implemented: Small contracting motions of a big muscle resulting in large amounts of transferred power. Actuating and timing the 16 muscles strands of the main flight muscles independently in combination with rotating the wings at the joint base allows for unparalleled ranges of motion and complex maneuvers. The side tail feathers are actuated similar to the main flight muscles dividing the task of performing the upstroke and downstroke over muscle pairs.

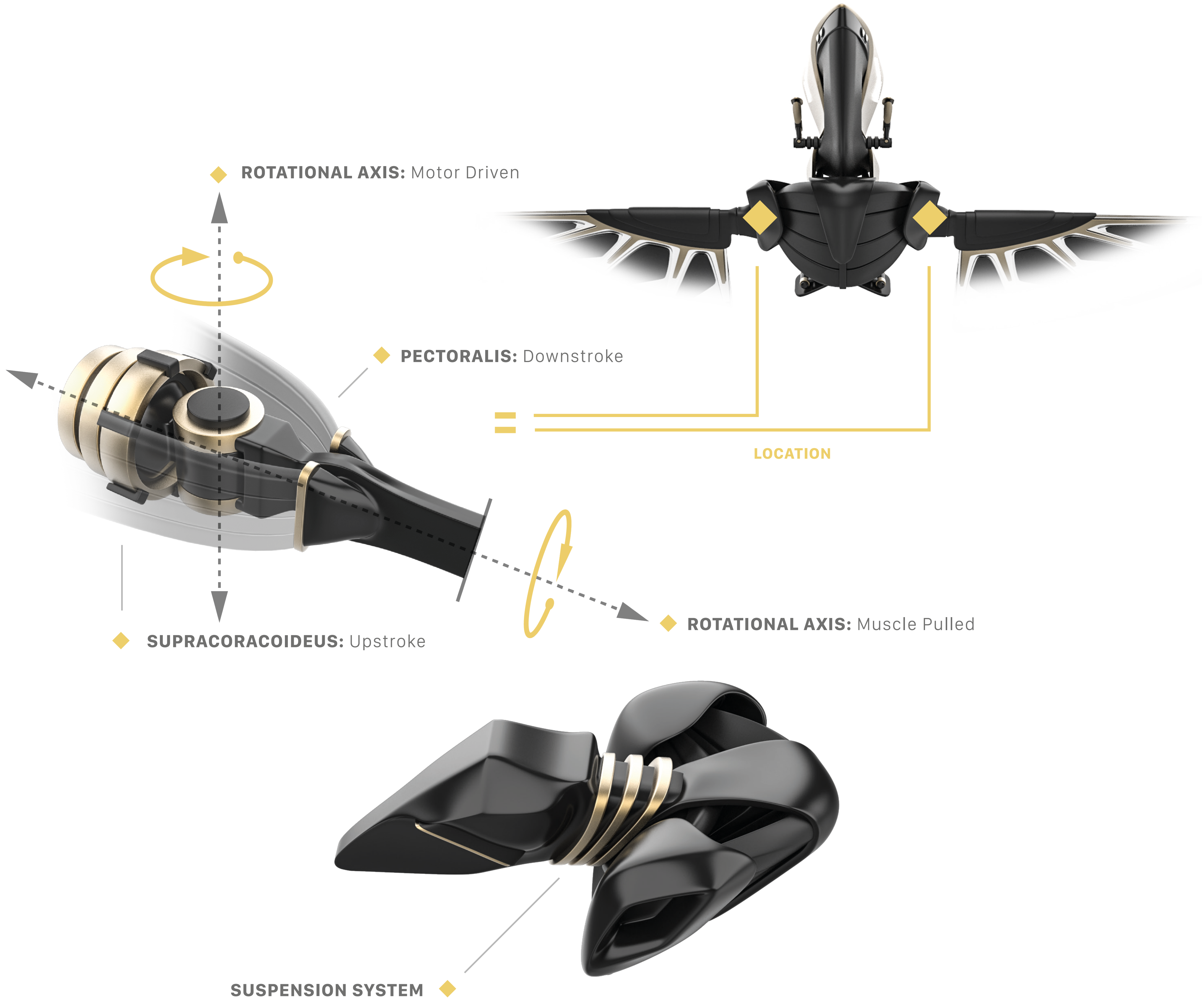




05

// JOINTS

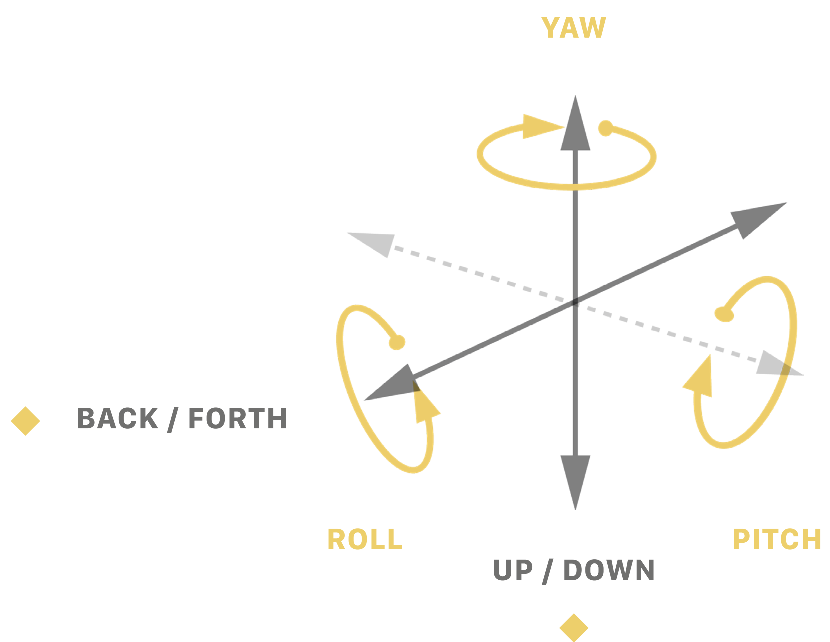
The two axis joint structure at the rear ends of the actuation system pose an integral connection between the wings and the muscle, by providing the necessary degrees of freedom to enable complex flapping patterns. With one activly motor controlled axis and one muscle pulled wing connection axis all functionalities can be achieved. The fast flapping motion of the wings with sudden changes of direction and velocity transfers large amplitude and high frequency vibrations to the muscles system. To counter this vibration and to avoid nausea and dizziness in the pilot a suspension and vibration interfering device is located between the main structure and the muscle system. With the help of such a buffer only minimal vibration is transferred to the pilot´s body.

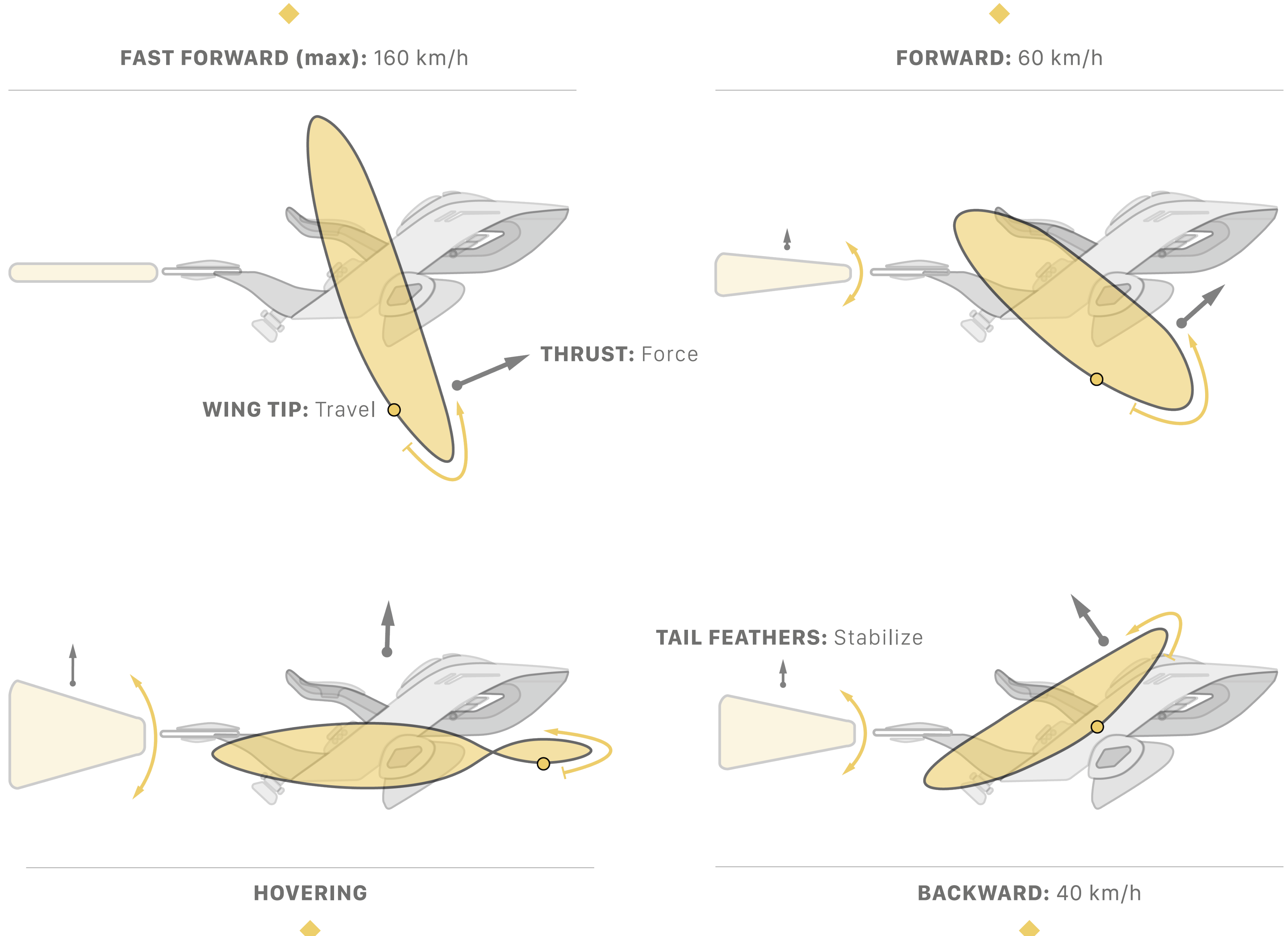


06

// RANGE OF MOTION

By changing the angle of attack of the reciprocating flapping motion the “Hermes” flying solution can alter speed and direction. The resulting ranges of motions are actually comparable to those of a hummingbird. Airborne mobility features high maneuverability and a novel flight experience. In comparison to an airplane´s standard 3 Degrees of Freedom (roll, yaw, pitch), the “Hermes” flying solution features additional 2 Degrees (forward/backward, up/down).





5 POWER PLANT

01

// HYDROGEN STORAGE

Storing hydrogen in high densities requires high levels of pressure (500-700 bar). Therefore, the dedicated tank must be able to withstand these pressures, preventing leakage and minimizing safety hazards. Reinforced with a carbon-fiber-composite and topped with rigid aluminum capsules the structure is able to do just that. Located on the rear of the tank the valve system controls the inflow and outflow of the hydrogen in gas form.

02

// FILLER SYSTEM

Featuring the filler cap and transmission hoses the filler system is tasked with sensing, distributing and managing the high-pressured hydrogen at the neuralgic points. The upper two hoses guide hydrogen during the refueling process and lead it to the tank located under the main unit, while the two hoses in the middle regulate the hydrogen flow to the P.E.M Cell. During the energy conversion, the main emitted product (water) is channeled to the excess vents at the bottom of the flying solution.

03

// P.E.M FUEL CELL

At the core of the hydrogen power plant the proton-exchange-membrane cell stack is located. While the highly efficient and direct conversion of potential chemical energy into electric energy is performed with just water as emission, the fuel cell can be directly implemented in the electric circuit of "Hermes" to power the logic unit, lights and muscles. The chemical process is quite simple: Pressurized H2 gas flows along the anode and is split into two H+ atoms and two electrons. The electrons travel through the anode into the circuit to power lights, muscles and logic. On the cathode-side O2 gas is forced through the catalyst and forms two negatively charged O2 atoms. Two H+ Ions are thus attracted by the negative charge of the O2 atoms and travel through the membrane to form H2O in combination with two electrons and the oxygen atoms. Besides high efficiency and eco-friendly emission, the biggest advantages of such a power plant are its high energy and power density, both of which are required to allow for energy intensive flight states such as take-off, hovering and landing.

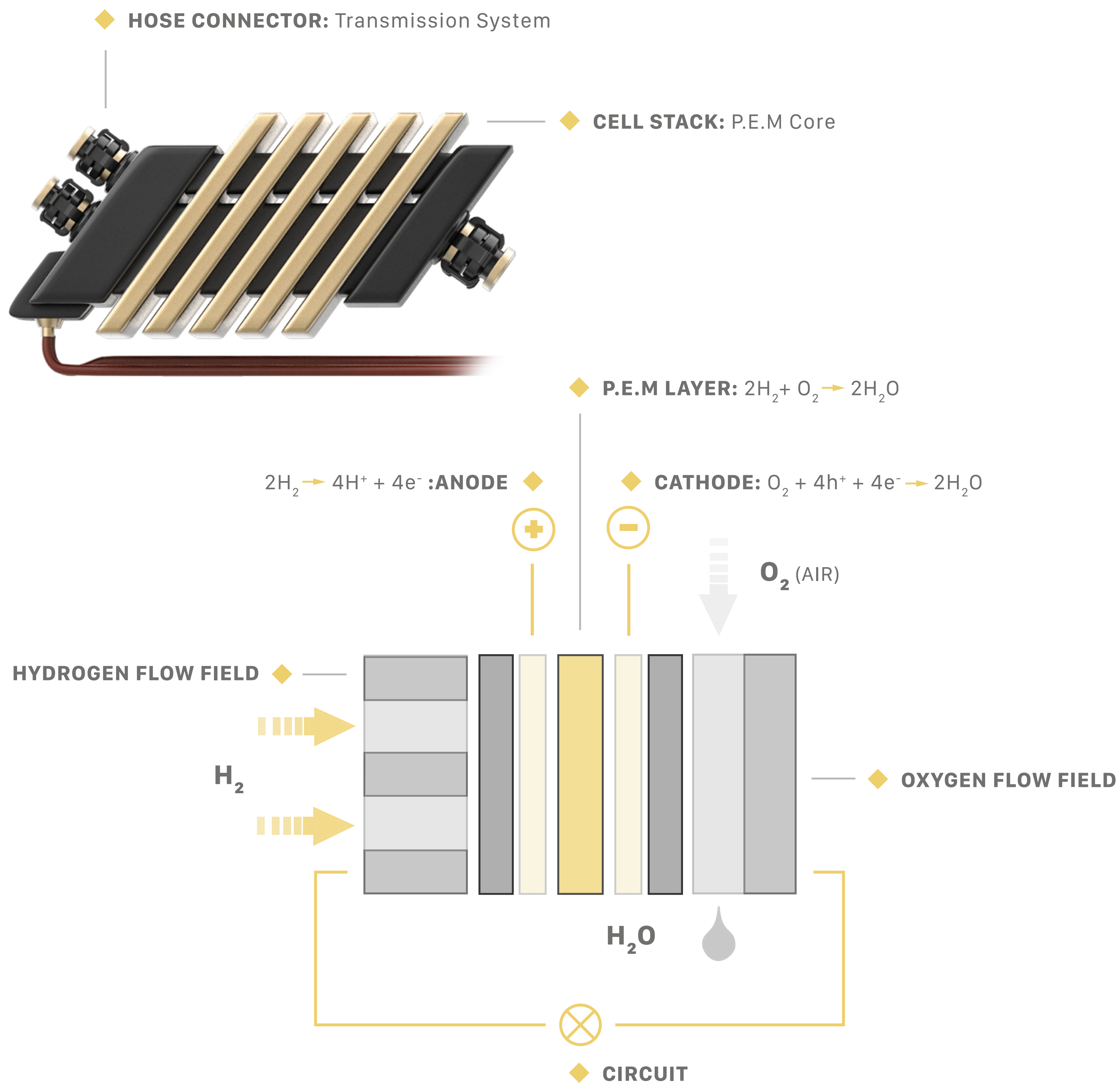


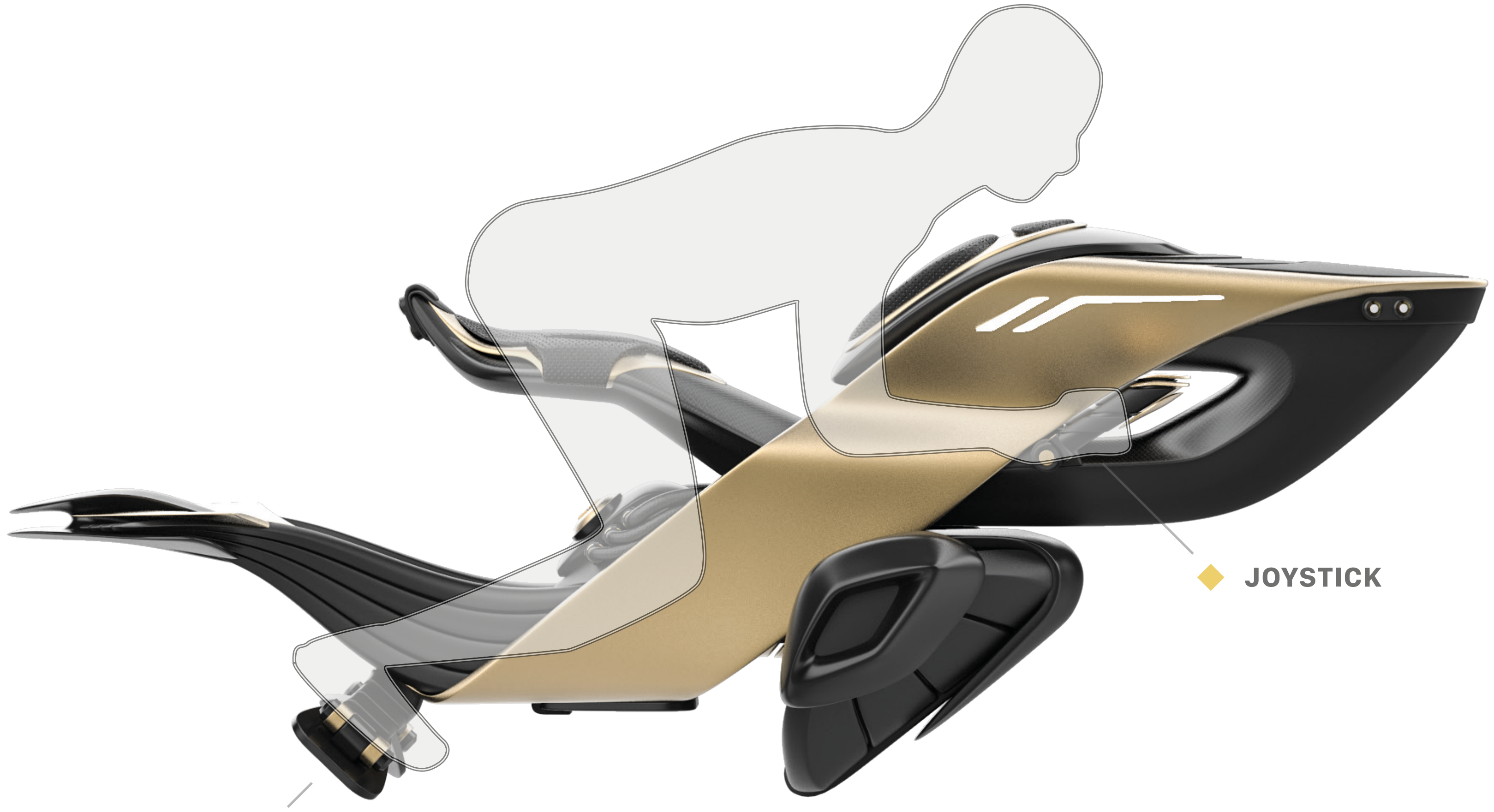
FIG. 2 // P.E.M FUEL CELL

6 ERGONOMICS

01

// SUPPORTS

Located at the rear of the main frame, the seat cushion array's main function is to support the pilot´s body safely and comfortably. Consisting of the seat, thigh- and chest cushion the design supports the body on neuralgic points. In high velocity flight, the pilot may rest his chin on the dedicated support integrated in "Hermes´s" head. To avoid distracting light reflection that may cause safety hazards for the pilot during flight, the anodized aluminum ribbon is topped with a rough black structure to absorb the sun light. The position and range of motion of the wings allow for a safe buffer distance to the pilot´s body. If the pilot remains within the confines of this safe zone, there is no danger of complications or safety hazards.



02

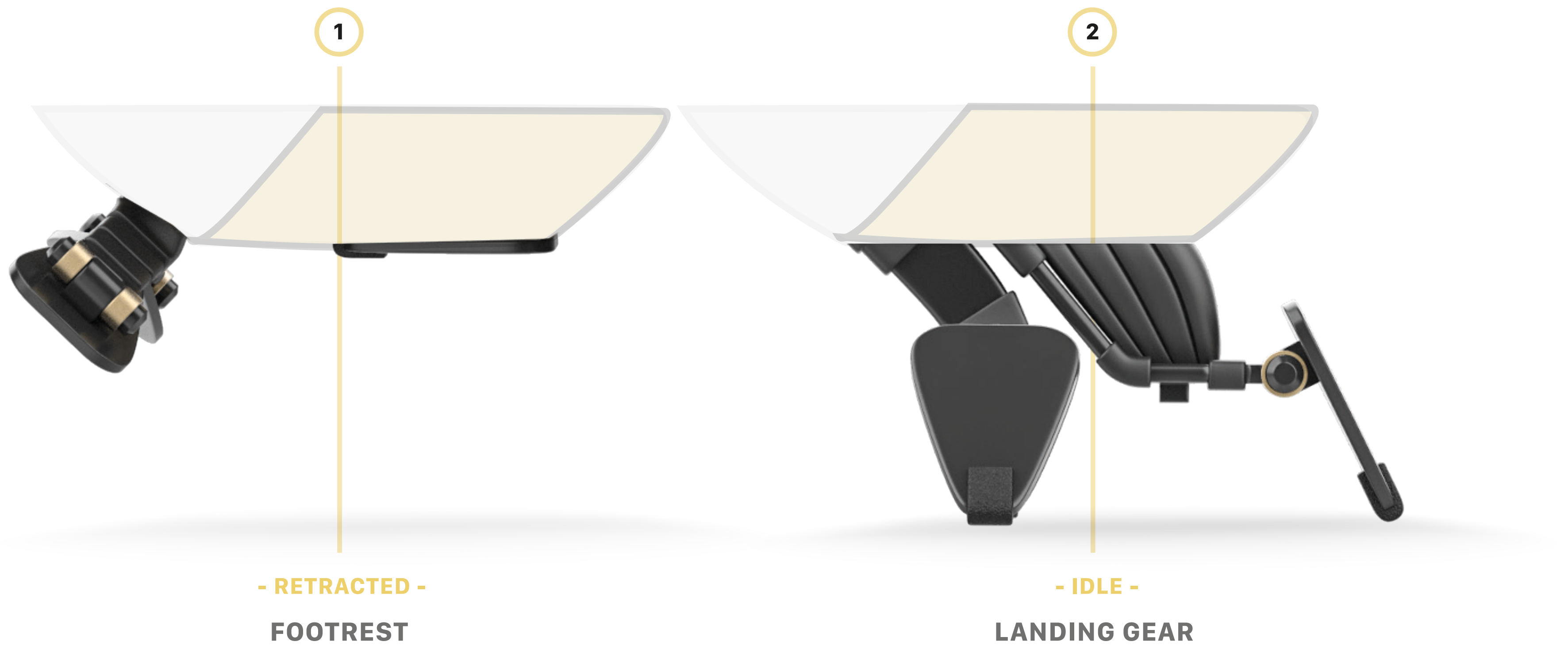
// MAGNETIC FOOTREST

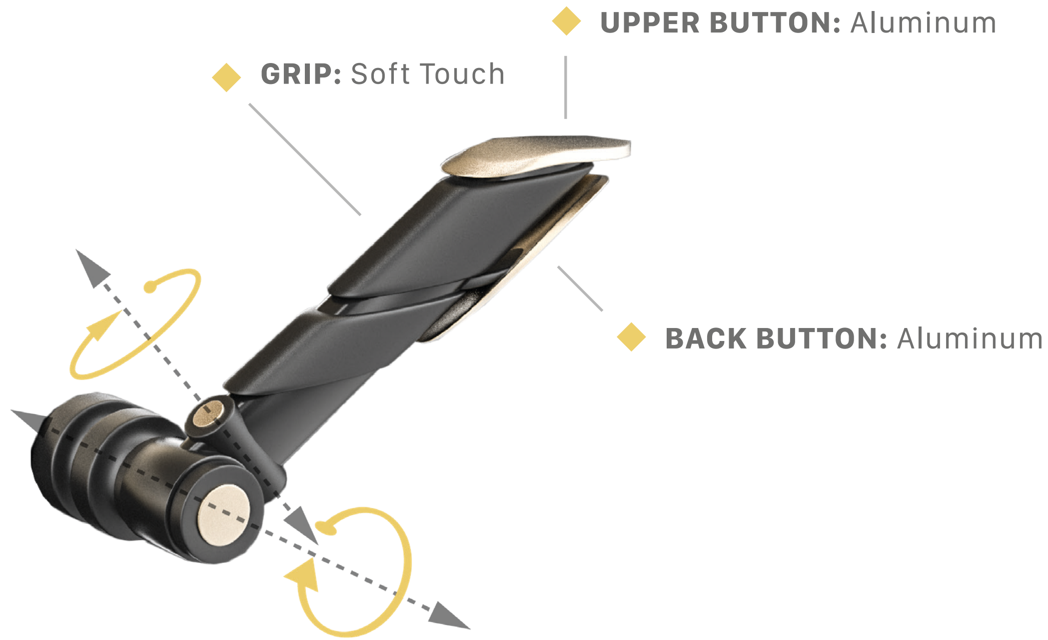
Doubling as footrest during flight and main weight bearing component of the landing gear in idle position the retractable system features dynamic shifts in between states. A magnetic locking device is installed on top of the footrest to adhere to a corresponding piece integrated into the boot that has to be worn by the pilot. By creating such a tight bond between "Hermes" and the pilot, overall safety and comfort during flight is greatly improved.

03

// JOYSTICK

Aligning to the signature ribbon of the solutions frame, the Joysticks can be gripped easily and without causing discomfort to the pilots when in resting position. Because the pilot is secured to the solutions body via the magnetic footrest and comfortably rests in-between the support cushion array, no additional gripping force has to be put on the Joysticks during flight, which otherwise could greatly compromise the pilots ability to control "Hermes".

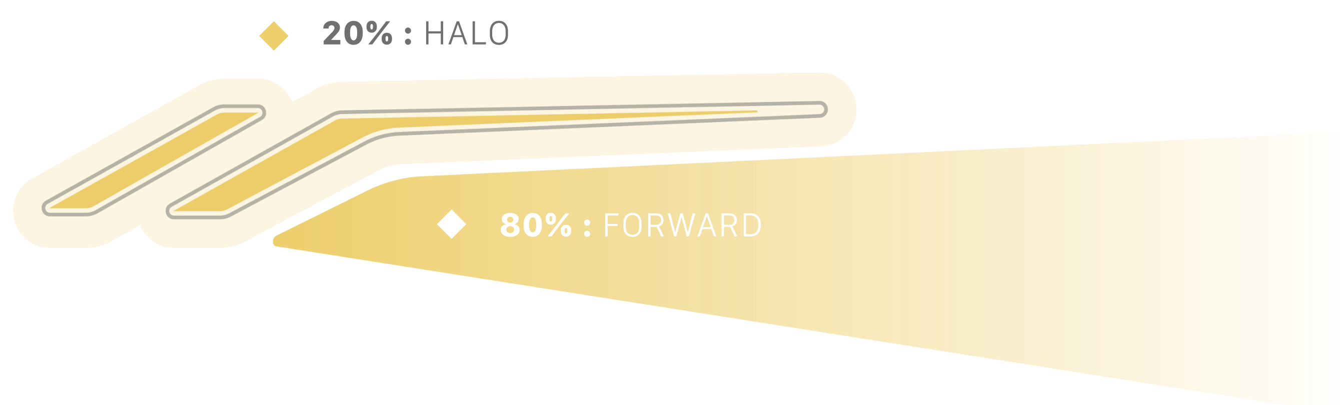




04

// LIGHT SYSTEM

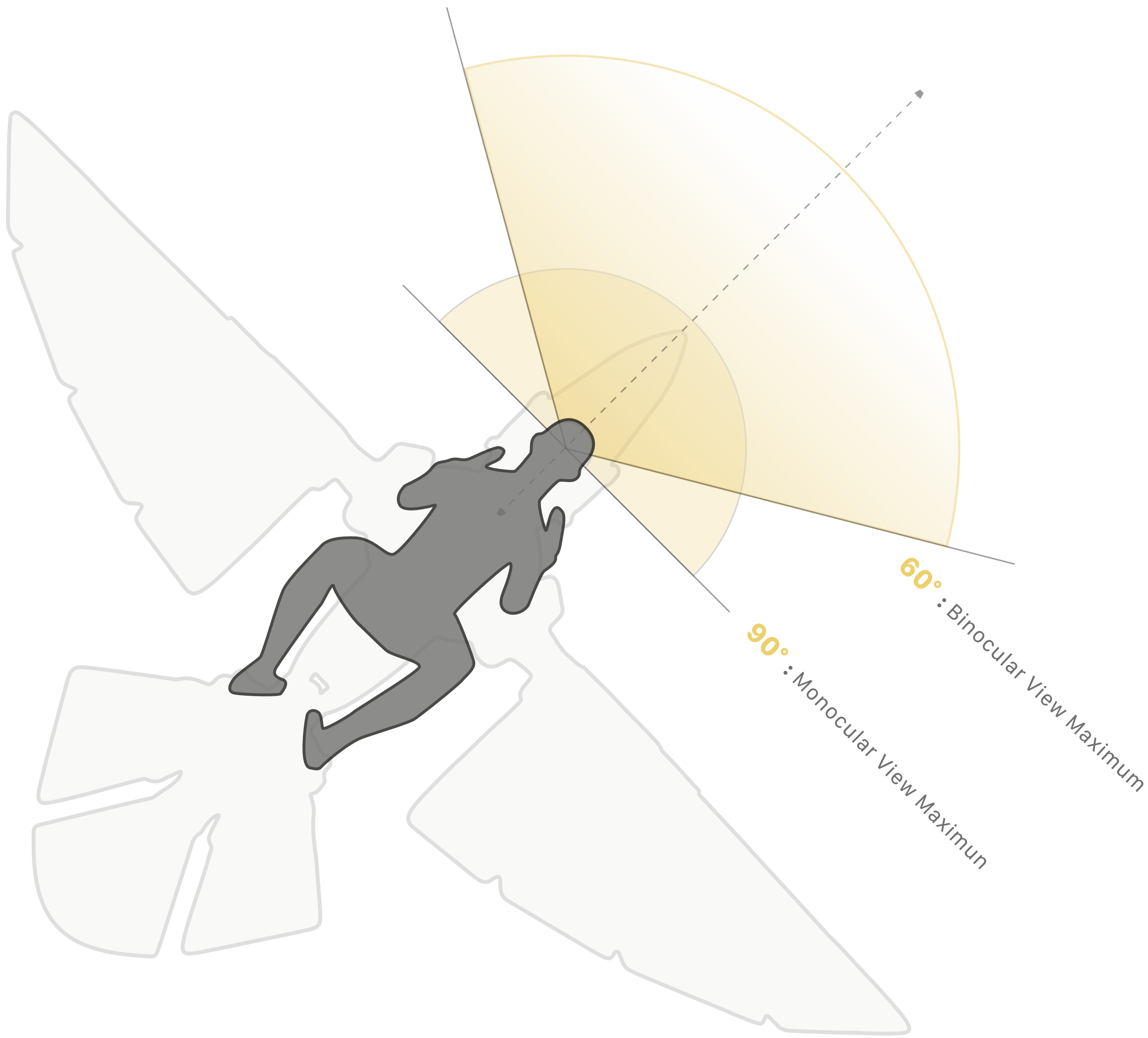
The design of the Lights on both sides of "Hermes´s" head emphasize the biomimetic resemblance to the hummingbird. While 20% of the emitted light is surrounding the LED-Arrays to underline this „eye"quotation, 80% of the light is directed forward to allow for good orientation even in low sight scenarios. To help the pilot grasping the wing span more easily and calculate maneuvers in confined environments the tip of the feathers of each wing can be lit as well. In low sight scenarios this may also increase visibility of "Hermes".



05

// FIELD OF VIEW

As any aviating machine, "Hermes" has to provide a maximum field of view for the pilot. Technical assistant devices notwithstanding, he must be able to find his way by mere vision, identifying obstacles in time. To meet these criteria, the head of "Hermes" is short and slim creating minimal visual blockage. Because there is no other confinement to the pilot´s field of view in flying position, an almost 180 Degree Field of View is ensured.



7 SAFETY

01
// SENSORS

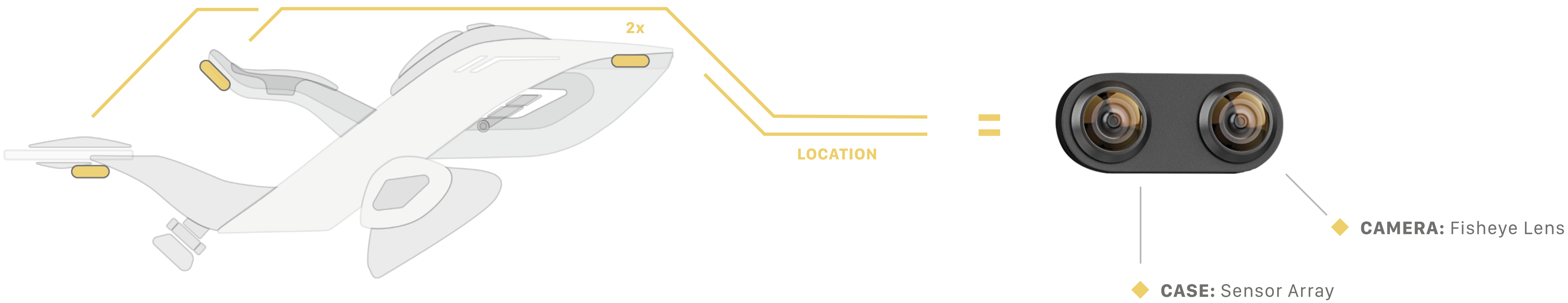
Equipped with a sensor and processing unit located at beak of the "Hermes Solutions", the internal logic and flight control device is able to actively sense and process its environment. The two cameras at the beak interact with an additional pair on the rear seat, and another one at the bottom directed downwards. Together with GPS Sensors (Location Information) and a Gyroscope (Orientation Information) the sensor array is able to visually capture the surroundings with a 360 Degree Field of View on all axes.

02
// INTERPRETATION

The constant data stream of the visual and spatial information is than interpreted by the processing unit and a special algorithm. Besides velocity, rotation, location and altitude, the main output of the software is a real time updated 3D Map of the terrain below, as well as an active weather forecast based on visual interpretation algorithms of the camera array and data from the Internet of Things. Additionally, the system indicates other flying vehicles or animals detected in the "Hermes´s" surroundings. The gathered information is transferred into the User Interface of the W.I.A.R Glasses of the pilot.

06
// PASSIVE FLIGHT ASSISTANCE

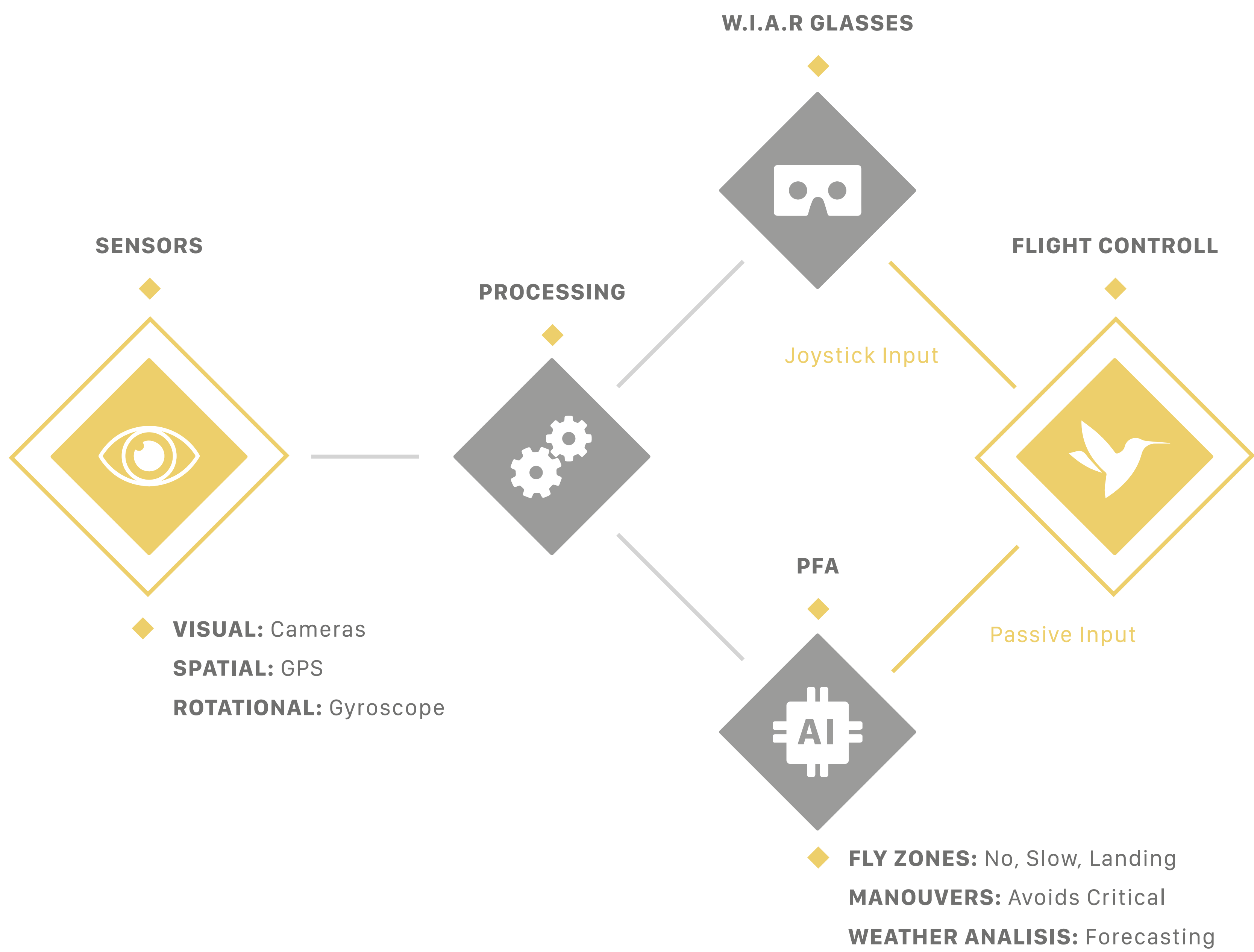
The information processed by the interpretation algorithm is continuously fed into the flight control system tasked to actuate the wings and perform complex motion patterns. Based on the constant livestream of data the intelligent "Hermes solution" is highly reactive to its environment. Such as a horse will refrain from doing too dangerous things even when forced by the rider, "Hermes" has an inbuilt set of confines limiting drastic changes of velocity or rotation that could potentially harm the pilot or knock him out of his seat. The terrain and obstacle detection will also minimize the danger to collide during flight.



03

// NO FLY ZONES

The quality of gathered data and the active connection to the internet allows the implementation of GPS based No Fly, Slow Fly or Landing Zones. With the help of this system, the use of the "Hermes Solution" above densely populated areas or in case of local overcrowding of the airspace allotted to ornithopters can be regulated. For example, if a pilot tries to enter a No Fly Zone "Hermes" will automatically throttle speed until hovering at the fringes of the restricted area, even when the pilot tries to force prohibited actions. The same concept applies to speed regulations in Slow Fly Zones as well as Landing Corridors in the respective Areas. Regulatory issues in the adoption process of "Hermes" could be minimized when governments and cities make use of implementing Fly Zones over dedicated areas.

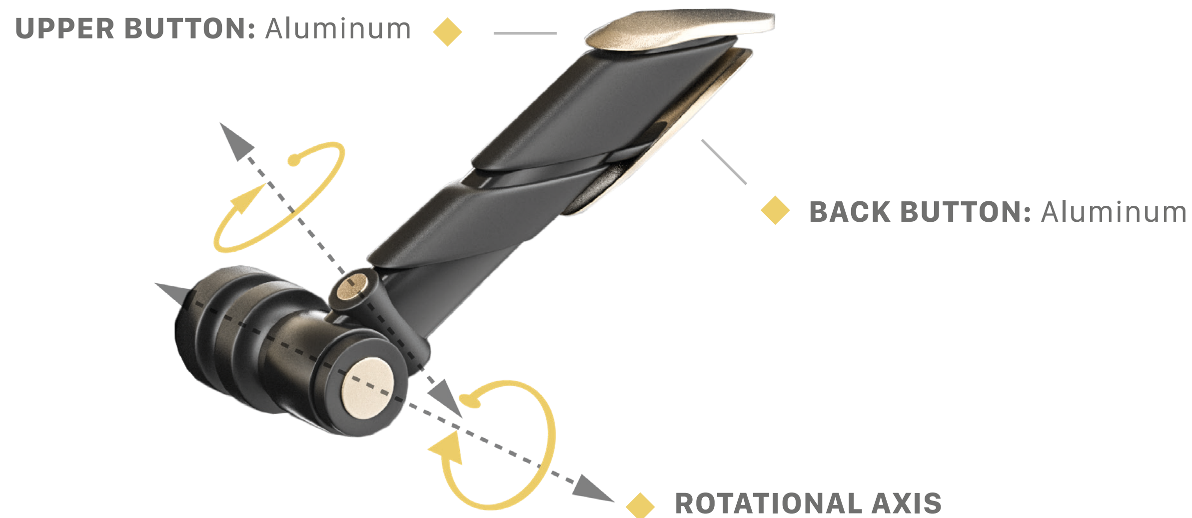


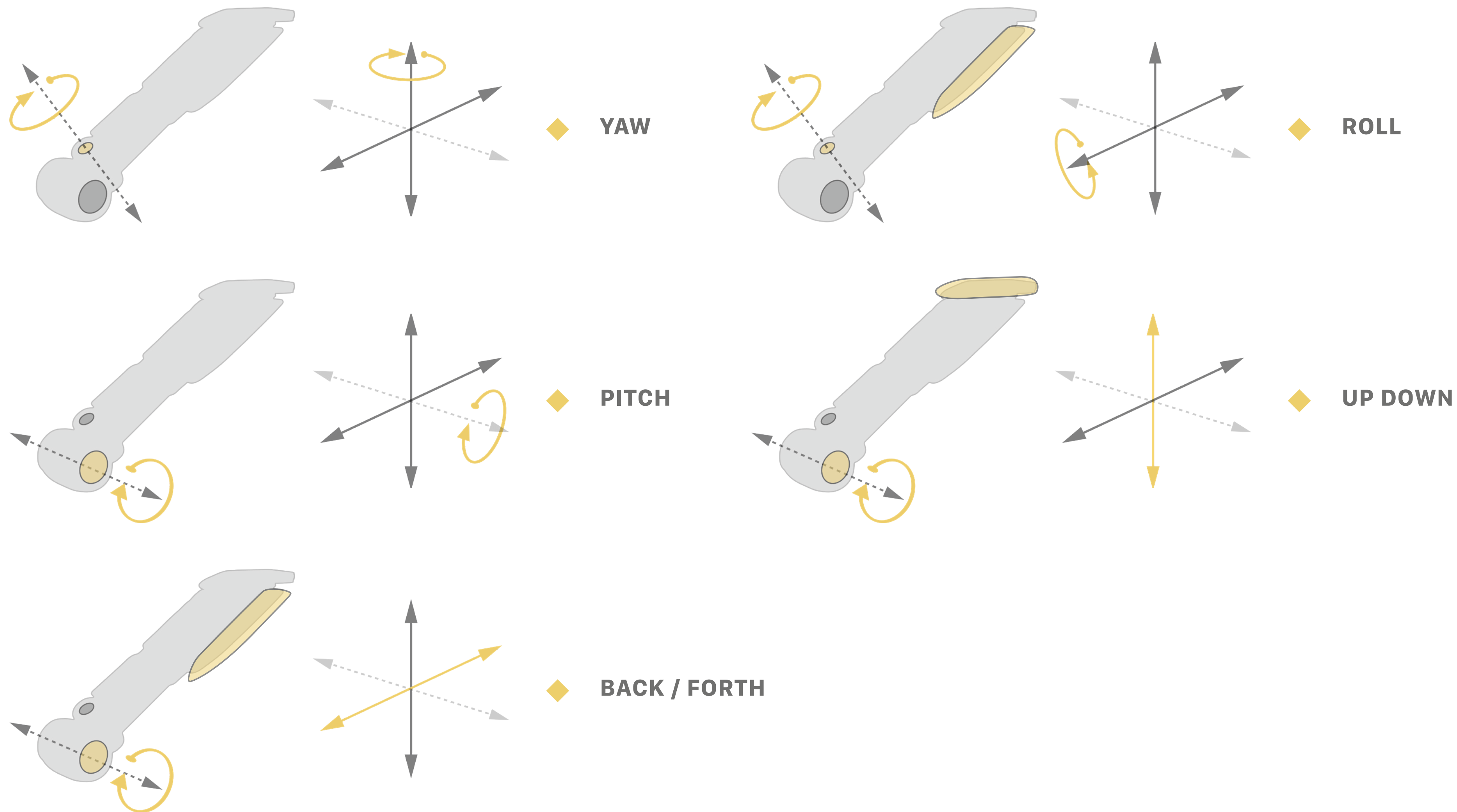
8 INTERFACE

01

// CONTROLS

The joysticks with two rotational axes and two buttons enable 5 degrees of freedom. Both handles are synchronized to minimize the danger of unwanted flight moves in mid air. Without pressing a button, yaw can be controlled by moving the handles left or right. Pitch is controlled by pulling or pushing the devices from or towards the pilot´s body. If both back buttons are pressed and held, forward and backward motions can be altered with the same movement pattern that controlled pitch in the previous state. Moving the handles left and right with the back buttons activated controls roll. Pressing the Upper Button unlocks altering of Up and Down movement.





02

// W.I.A.R GLASSES

As the main body of "Hermes" features no display, the pilot has to use wearable immersive augmented reality (W.I.A.R.) glasses to get information about relevant parameters. The pilot is provided with information about e.g. energy consumption, flight paths, velocity, rotation, altitude, weather and other flying objects or birds W.I.A.R glasses are an optimal choice in aviation scenarios for they offer a distraction free User Interface that can map data to their origin and conveys information on time and more clearly than other fixed display solutions.

03

// SKILL LEVEL

Because maneuvering the "Hermes" ornithopter will require practice, the user can choose different levels of Passive Flight Assistance. Ranging from completely automatic landing and take-off and locked degrees of freedom (like e.g. no „roll" option) for beginners, more experienced pilots may find it interesting to reduce the Passive Flight Assistance to the minimum. The Hermes Solution does also include a „dry run training" on the ground, that unlocks the controls but only displays a tutorial-like computer simulation in the W.I.A.R glasses to train flight.

9 USABILITY

01

// PREPARATION

Before the pilot is able to mount "Hermes" and get airborne, he or she has to equip him or herself with the dedicated W.I.A.R glasses and the corresponding magnetic footpiece. Both essential devices are lightweight and comfortable to attach and wear.

02

// STANDING

In idle position "Hermes's" wings face sideways to minimize the overall footprint and avoid possible contaminations from the ground. The tripod-shaped Landing Gear Structure is in expanded position supporting the aircraft's weight. Thereby, enough clearance is provided to ensure a safe take-off procedure.

03

//MOUNTING

As the pilot approaches with his already activated W.I.A.R glasses "Hermes" spreads its wings and eases accessibility to the Footrest. After both feet rest firmly on the dedicated surface, the electronic magnet is activated, effectively locking the bond between pilot and "Hermes". After an automated system check, the signature light array illuminates and communicates "Hermes's" ready-to-flight condition.

HERMES: Idle Position

04

// TAKE-OFF

The initial ake-off procedure is automated by the passive flight control system until a clearance of 2 meters from the ground is achieved. While the main wings start to flap rapidly, the tail side feathers are actuated additional to sustain the aircrafts balance. Shortly after take-off, the legs of the landing gear are retracted thus bringing both the pilot and "Hermes" into flying positions. After achieving the required flight-level above the ground, the pilot may take control of the aircraft.

06

// LANDING

Like the take-off procedure the final landing sequence is automated. As soon as 2 meters ground clearance in a landing zone are hit, the wings sustain their high flapping rate until the legs and feet of the landing gear have made safe ground contact.

05

// FLIGHT

During flight the pilot is constantly guided by the passive flight control system, whereas the W.I.A.R glasses and the handle bar interface enable and support safe navigation.

HERMES: Flying Position

10 FEATURES

01

// EXPERIENCE

The “Hermes Ornithopter Aircraft Solution” offers a novel experience. It will not only be the first ornithopter aircraft with high accessibility, able to land on a small footprint. The true potential of the idea lies within the careful balance between human input and artificial intelligence’s guidance. While ensuring safety is still a central part of the concept ”Hermes” does not override humans input to the extent of machine autonomy. The aircraft will be highly “intelligent” in terms of active sensing and interpretation while giving room for an individual´s desire to explore and navigate the most efficient path to a chosen destination. Furthermore, the biomimetic design based on the hummingbird will allow for roaming the air freely as a bird, a desire deeply rooted in humans.

02

// GLIDING

While this ornithopter may still maintain hovering states as energy intensive as a multicopter drone, the potential to save significant amounts of energy over long distances lies in the use of its gliding capabilities. This offers a considerable advantage in comparison to multicopter drones the energy consumption of which remains more or less constant during different manoeuvers

03

// NOISELESSNESS

Although it is hard to predict how much noise the final version of the “Hermes Solution” will actually create, it is safe to presume that the gliding state will be almost noiseless in comparison with a multicopter drone of equivalent size and application during flight.

04

// INTEGRATION

Because of the low noise and low energy consumption, the "Hermes Solution" will be perfect as a one-person commuting vehicle, to get from rural areas into the city and back again. As urbanization is one of the biggest future trends, it is not hard to imagine how much impact this solution could have: It is easily accessible and capable of noiselessly gliding above jammed streets. Moreover, it only requires a small footprint for landing. The use of "Hermes" could be alleviated by a city´s or government´s willingness to mark territories via GPS as No Fly, Slow Fly or Landing Zones.

04

// MANOUVERABILITY

The "Hermes" flying solution offers new flight patterns. The wings´ significant range of motion allows for aeronautic maneuvers like e.g. nose-dives or quick changes of direction in tight spaces.

11 FEASIBILITY

01

// MUSCLE SYSTEM

The invention of the H.A.S.E.L Muscle and its simple functional principle pose a solid foundation for the development of more sophisticated versions. Yet abundant resources are required until muscles as strong, reliable and fast as the ones implemented in the "Hermes" solution can penetrate mass markets.

02

// POWER PLANT

The physical storage of the hydrogen in combination with the P.E.M Fuel Cell is an already tested and implemented solution in the automotive industry. Therefore it is safe to presume that the power plant is at a technically feasible state.

03

// AERODYNAMICS

The Aerodynamics of "Hermes" (in particular the reciprocating hummingbird flight pattern at this scale) are complex and difficult to effectuate with today´s tools and knowledge. There has to be a stronger basis of experimentation and prototyping until this flying behavior can be put into practice in a customer-ready vehicle for the required amount of flight time.

04

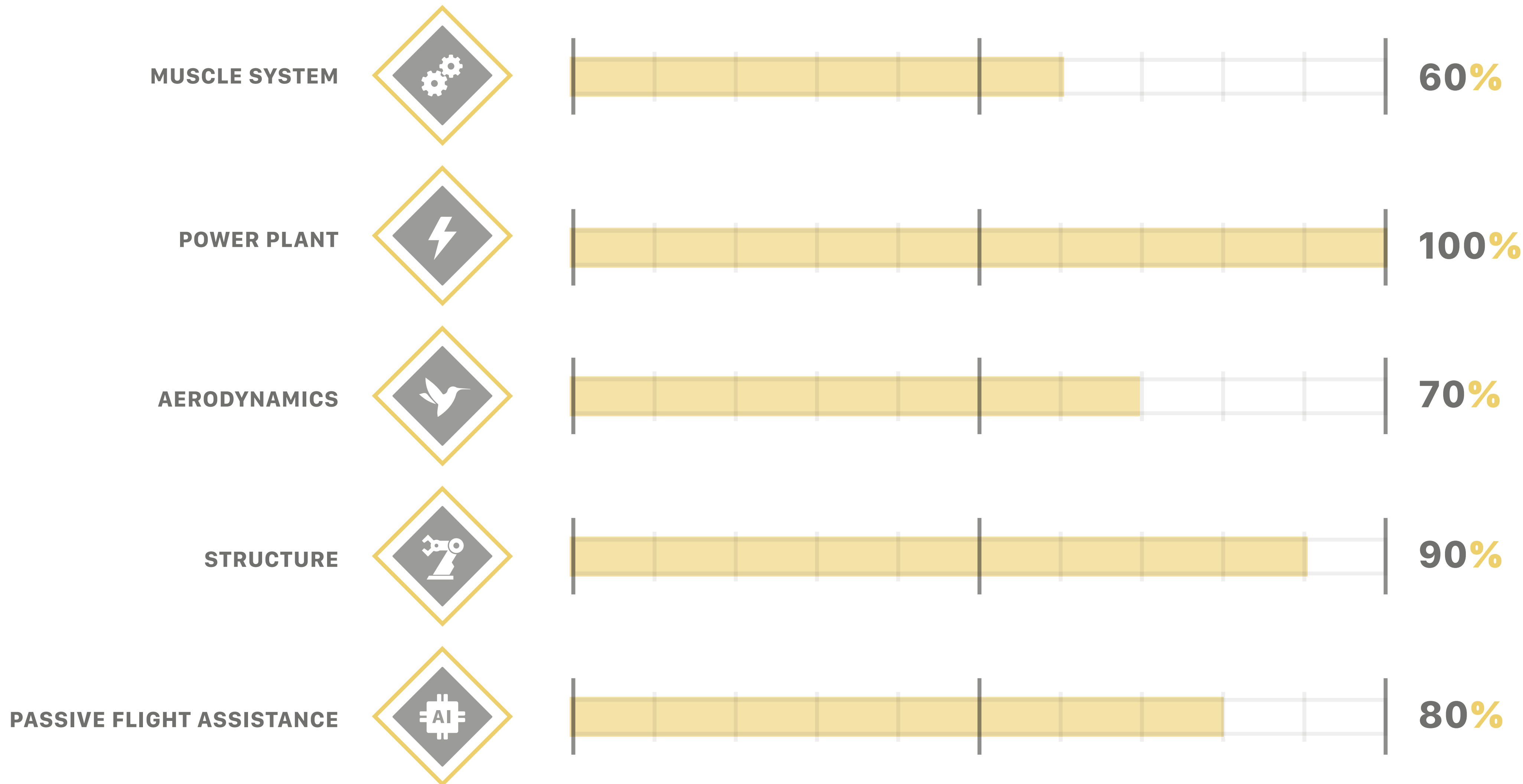
// STRUCTURE

The main structural components of "Hermes" offers no big challenge for today´s manufacturing standards. Using 4D printing to aid the production of intricately layered parts of the vehicle, such as the muscles system, will require more research and development.

05

// PASSIVE FLIGHT ASSISTANCE

The hardware, software and firmware interaction of the "Hermes" system is based on implemented solutions used in today´s multicopter drones. Solely the artificial intelligence visual interpreter to generate life and accurate weather forecasting as well as to identify objects will require more sophisticated development.

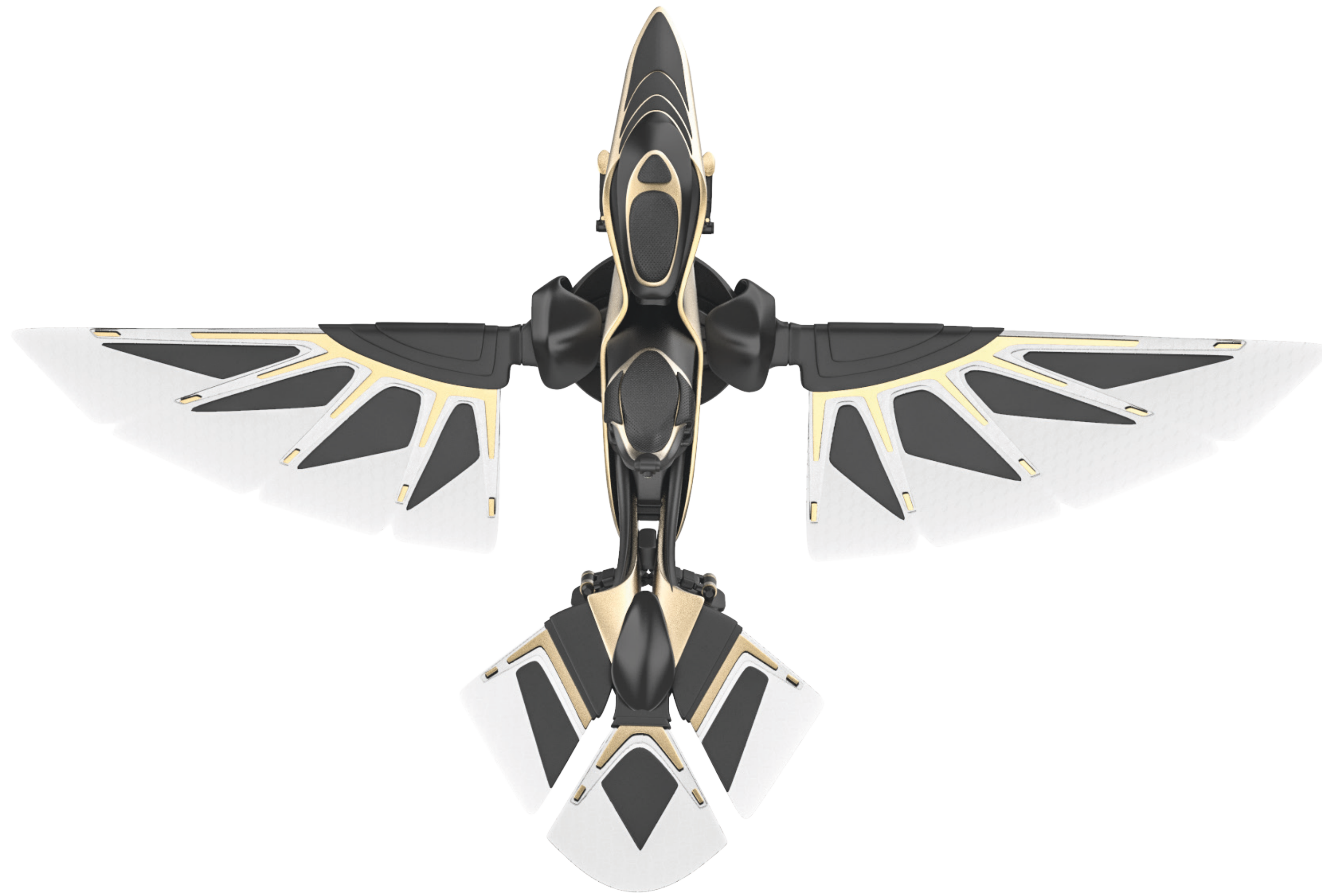

MUSCLE SYSTEM
60%
POWER PLANT
100%
AERODYNAMICS
70%
STRUCTURE
90%
PASSIVE FLIGHT ASSISTANCE
80%

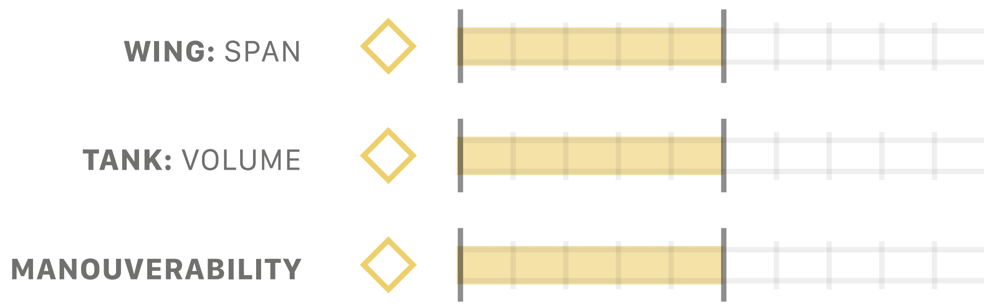
12 USE CASES

01

// COMMUTE

The basic version of "Hermes" with an average wing span and a medium sized hydrogen tank would be well suited to support commuting from rural areas into the city, or from office tower to office tower. If the solution would be widely adopted in a metropolitan area, it could be helpful to erect dedicated infrastructure, like hydrogen refilling stations. An average flight time of 30 minutes could be expected of such a use.



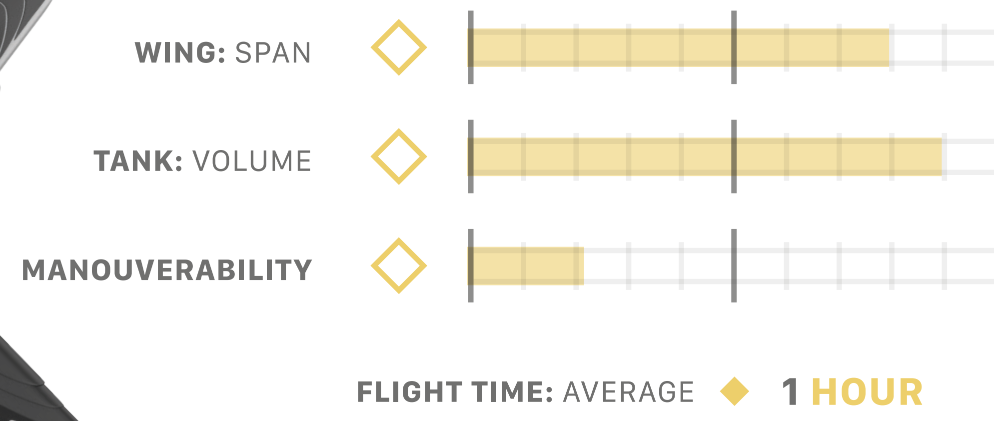


FLIGHT TIME: AVERAGE **30 MIN**

04

// EXPLORATION

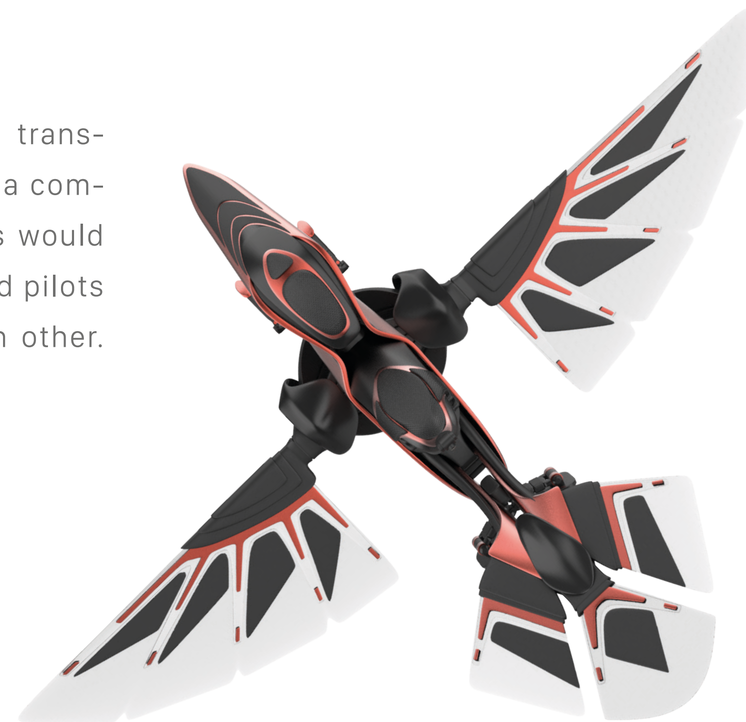
By increasing the wing span and implementing a stronger muscle system, the "Hermes" would be equipped to ensure longer flight times of up to 2 hours while featuring increased payload capacity. Such a version could be used for exploration of inaccessible regions and areas, or even for disaster intervention by dedicated organisations.

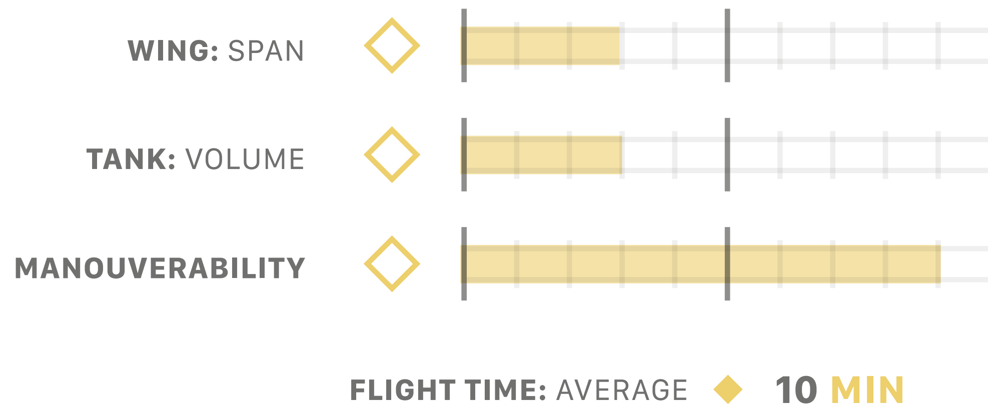


03

// SPORT

Shorter wings and a smaller, less heavy tank would transform "Hermes" to be lighter and more agile. Creating a competitive scenario with high velocity obstacle courses would make up for spectacular competitions in which trained pilots use the sport version of "Hermes" to challenge each other.





0 CONCLUSION

CO

// HERMES

Individualized, ecologically sound flying solutions could alleviate transportation problems arising in future overcrowded megacities. They have to be easy to operate and ready to use. They must enable nimble and quick maneuverability while occupying a minimum space for take-off and landing. They must neither emit noise nor ecologically incompatible exhaust and finally they have to ensure maximum safety and comfort for the pilot. The present "Hermes flying solution", a novel flying concept based on the flight of the hummingbird complies with these requirements. Its design is both evocative of a bird and a motorbike, suggesting a fusion of technological and biological properties. P.E.M. hydrogen fuel cell (proton-exchange-membrane cell) power generation, H.A.S.E.L (hydraulically amplified self-healing electrostatic actuator) actuation of the moving parts as well as a sophisticated system of sensors feeding into a passive flight assistance system and into W.I.A.R. (wearable immersive augmented reality) glasses are the crucial elements of the solution. Though not all components needed for realization of the project are available at present, developments indicate that they will be in the near future. I do believe, that this innovative design can be put into life and that it may open the door to novel aspects of individual transportation.

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HERMANN DREAMA

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FIGURES:

FIGURE 1:

Based on CFD analysis with Autdesk Flow Design:

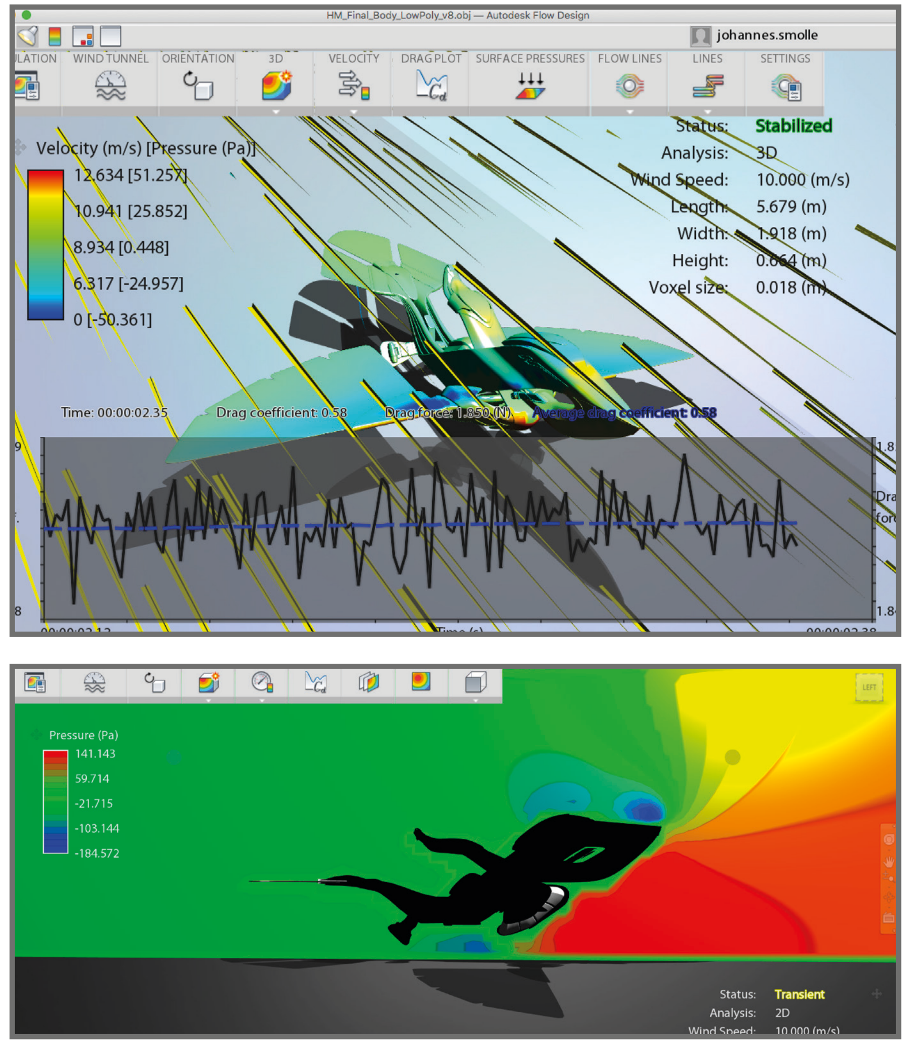

FIGURE 2:

Based on a functional graphical depiction of a P. E. M Cell from: Hydrogenics. Fuel Cells. Retrieved September 05,2018, from https://www.hydrogenics.com/technology-resources/hydrogen-technology/fuel-cells/