Group 1 – Defend Our Territory

June 20th, 2019

Asteroids are of great value for scientific purposes, for they can be considered as the building blocks of life on our planets and can therefore provide valuable insight on the origin of our solar system and on its evolution. They are also, on the other hand, a threat to us, through their risk of potentially hazardous collision with Earth.
To assess characteristics such as their size, orbital period, and semi-major axis, the light they emit is observed by remote instruments such as telescopes. However, the data found only gets more accurate as their approach to Earth increases. Today's asteroid databases are thus found to be quite inaccurate, especially for small asteroids, reducing our ability to predict in detail a potential forthcoming crash before the asteroid's actual close approach to Earth. Hence, improving today's asteroid characterisation methods is of utmost importance for avoidance of such a catastrophic event.

A cheap and new mean of access to space is simultaneously making its way to the top of the space sector. Measuring no more than 5 cm cubes, PocketQubes represent today's lightest, cheapest and possibly smartest way to get equally small scientific instruments in orbit.
Combining the two aspects of filling in the present knowledge gap on Very Small Near Earth Objects, and of demonstrating the promising technology of PocketQubes led to the *Defend Our Territory* mission, and more specifically to the ***ANTREA*** design.

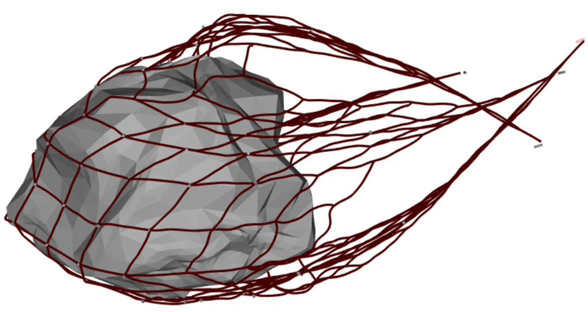


Figure 1 – *ANTREA* landing on asteroid, created in cooperation with *SKA Polska*

Leaving Earth in May of 2033 for a planned arrival to asteroid *2017FU102* in April of 2036, ***ANTREA*** consists of a 15 x 15 m net, which was found to be the most fitting way of landing on the asteroid, mainly considering its fast rotational rate and non-existent gravity pull. The net will wrap itself around the asteroid, with 69 PocketQubes weighing between 150 g and 180 g attached to its nodes. These will then measure crucial properties such as the asteroid's shape and size, its surface composition, hardness, temperature distribution, dynamics and internal materials, with aim to characterise it in a distributed way. Our team designed the net itself, its deployer from a compact 27 L available volume in the Mothership that will take it to the asteroid, as well as the PocketQubes' subsystems such as their structure, electrical power system, communication, thermal control, command and data handling, and payload instruments.

At the moment of writing this jury summary, our team has finished all design iterations. In the next few weeks, we shall analyse the design of operations and logistics of the mission, the market analysis, sensitivity analysis, performance analysis, manufacturability, risk, redundancy philosophy and reliability, and sustainability approach of the design, finalise its detailed Catia drawings, as well as the net deployment simulations.

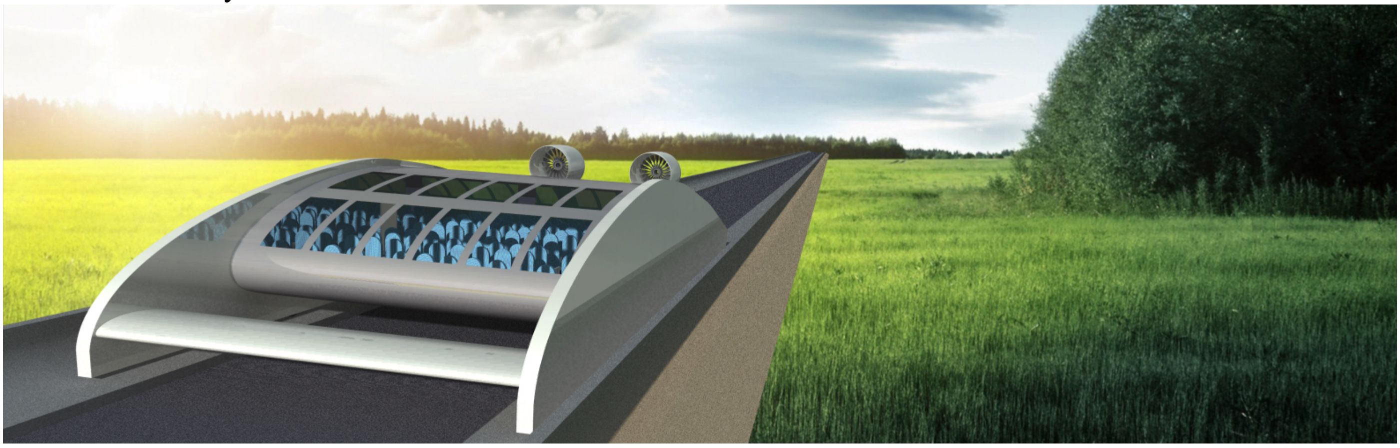
We look forward to presenting you the final design and convince you that it can perform its intended use and advance the frontier of miniaturised spacecraft and asteroid knowledge!

AeroCity

Year: 2018-2019
DSE Group 02

The current transportation network faces many challenges regarding pollution, noise and costs. The limits of current transportation systems are being pushed. The increasing number of people travelling regularly makes clear that new transportation systems must be created to comply with customer needs. Expansion and innovation of transportation infrastructure are needed and future transportation should become more sustainable whilst also being cheaper, safer, and more reliable.

Examples of existing transportation systems are the TGV and Maglev. These systems can reach speeds over 300 km/h. However, their infrastructure comes with a ridiculous price tag (6.6 billion Euros [1] for 100 km of track). The costs for the infrastructure increase exponentially with the maximum speed of these vehicles as the required tolerances become tighter.
This makes the break-even point very hard to reach and hence high-speed transportation systems are very unattractive for investors. The challenge is thus to design a new high-speed transportation system, one that matches speeds of current alternatives whilst at the same time reducing infrastructural costs. The proposed solution: AeroCity.



What is AeroCity?
AeroCity is the next chapter in High-Speed Transportation. It is a high speed and zero emission vehicle for 116 passengers with low infrastructure costs. Whilst Maglev and Hyperloop want to create lift magnetically to avoid friction, the AeroCity is an aerofoil shaped vehicle that creates its lift by using the Wing-in-Ground effect (WIG). Due to the WIG effect, AeroCity can hover approximately 5 cm above the track at 305 km/h cruise speed. Therefore, the necessity for an expensive magnetic levitation system (Maglev), vacuum pipe (Hyperloop) or train tracks with high tolerances is excluded. For this reason, the construction and maintenance cost of AeroCity's infrastructure is significantly lower.

The objective of this DSE was to design the power & propulsion system, controls, structure and operational management of the Aerocity vehicle and implement it to a transportation system designed for the route between Utrecht and Berlin.

Power & Propulsion System
The AeroCity vehicle is propelled by two electrically driven fans and powered by a swappable battery pack. This propulsion system allows for a decrease in infrastructure cost because no track electrification is required and the tolerances are lower.

Control & Stability
Since the AeroCity vehicle is flying close to the ground, a reliable control and stability system is required. Therefore, Aerocity makes use of a canard, ailerons, rudders and ballast. The main wing is able to rotate with respect to the side skirts in order to change the required lift coefficient during take-off, cruise and landing.

Structure
The lightweight structure enables the AeroCity vehicle to fly more efficient at an L/D of 25.5. By reinforcing the skin of the main wing, optimal passenger space is provided.

Conclusion
The AeroCity design is highly competitive and will redefine high-speed transportation in the future. So, next time when you are stuck in a traffic jam on your way to work just think that in less than 7 years you will be travelling with AeroCity!

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[1] '*Hogesnelheidheidslijn-Zuid: een rapportage in beeld*', Algemene Rekenkamer, June 2014

GROUP 03 - WATER BOMBER UAVS

WANGARI

A swarm of water bombing UAVs to revolutionise aerial firefighting

Summary

As the climate crisis worsens, a drastic increase in forest fires is observed worldwide. Firefighting aircraft can be an invaluable resource in fire suppression efforts. The vast majority of existing firefighting aircraft are not designed specifically for this type of mission. Old military aircraft have been refitted to carry and drop fire retardant, which hinders their competence in crucial aspects such as pilot safety, range, speed, and fire containment efficiency. Wangari, named in honour of the first African woman and the first environmentalist to win the Nobel Peace Prize, is an unmanned aerial vehicle (UAV) that excels at these parameters and revolutionises aerial firefighting with innovations such as tactical swarm attacks, night firefighting, and passively pressurised fire retardant drops.

Fire Simulation

In order to make decisions on the best strategies for aerial firefighting, and draw conclusions on the efficiency of swarm attacks, a fire behaviour simulation is developed and improved throughout the project to inform and verify design decisions. Fire spreading factors such as wind speed and direction, terrain elevation, fire fuel density, and water evaporation rates were studied, and mathematical expressions derived to describe fire behaviour. The result is a video simulation tool that can produce simulations for various fire scenarios.

Strategic swarm attacks

A fire attacking strategy is in development using the fire simulation to demonstrate the advantage gained by multiple UAVs dropping fire retardant simultaneously, over the conservative "bigger is better" approach of aircraft dumping larger volumes of water in fewer drops.

Innovative water operations

Wangari is able to land and take off on both land and water. Its small size (9m length, 17.5m span) allows it to land on smaller bodies of water, such as rivers. It can therefore quickly refill the 4500L water tank from a nearby source within 10 seconds, increasing its number of drops per hour. It uses its unmanned nature as an advantage to perform dropping manoeuvres and optimise drop efficiency (optimum litres/m^2) in a sustainable way, without the use of heavy pressurised systems.

Quickly on the scene

A fast spreading fire can burn through a forest with speeds up to 20 km/h [2]. For the initial attack, every second counts. Wangari has a maximum cruise speed of 112.5 m/s. This allows it to reach a fire 100 km away in under 15 minutes, 2 minutes faster than the most competitive alternatives.

Detachable structures for unmatched flexibility

The wings and the tail of Wangari are both detachable structures. A UAV can fit in a standard shipping container, and more UAVs can fit in one transport aircraft. This allows the system to be used in remote areas or deployed worldwide, while transported in an easy and sustainable manner.

Taking the pilot out of the aircraft to save lives

In the United States alone, 78 firefighting flight crew fatalities were recorded between the years 2000-2013[1]. Wangari is unmanned and therefore completely eliminates the risk of flight crew injury or death. To take further advantage of this, the UAV is well-equipped for night firefighting, which normally is highly restricted, limiting firefighting operations to only a few hours.

[1] Centers for disease control and prevention, MMW Report: "Aviation-Related Wildland Firefighter Fatalities – United States – 2000-2013"

[2] Phil Cheney, Andrew Sullivan, "Grassfires: Fuel, weather and fire behaviour ", Second Edition, 2008.

4-SPACE TRUCK

June 19, 2019

BIG PICTURE

The Vliegtuigbouwkundige Studievereniging (VSV) 'Leonardo da Vinci' has decided to develop, build and launch a CubeSat for its 75th anniversary in 2020. The mission is to bring space within the grasp of school children by providing a platform to set up experiments in space. This can be achieved by developing an ultra-reliable CubeSat bus, with capability to 'plug and play' a payload module. This module must have the potential to be designed, developed and realized by high school students within the constraints and limitations of the CubeSat bus.

OUR CONTRIBUTION

In collaboration with the VSV, the DSE project 'Space Truck' was designed to initiate and pave the way for the realization of the product. The name Space Truck reflects the capability of the CubeSat to carry multiple payloads which can function independently of each other. This DSE project covers the first phase of the big picture: project plan, baseline design, preliminary design of the CubeSat. The mission of the project is to formulate a design philosophy, develop a design and check its feasibility with insights from various experts from the space industry and academia. In doing so, it was realized that simplicity is the key to achieve an ultra-reliable design.

SO FAR...

The CubeSat is 2U (10x10x20cm) with the essential subsystems. It incorporates 2 payloads, one meant to answer questions posed by primary school children, and the other is to provide data that can be used in a study module for high school students. The payload modules consist of a programmable logic controller (Arduino Nano) connected to sensors. The first space truck should validate the functioning of the logic controller in such a setup. This would mean that any sensor, that can function and be programmed with a logic controller (easily operable by high school students) can be used as a 'plug and play' payload.

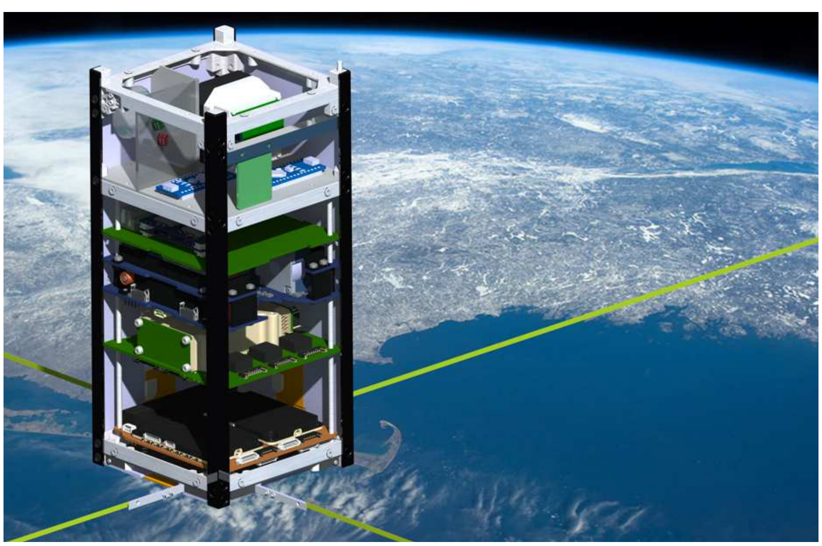


Figure 1: Rendering of Space Truck without solar panels

OUTLOOK INTO THE NEXT FEW WEEKS...

- To develop a Product Design and Development (PD&D) logic
- Manufacturing, assembly and integration plan
- Cost breakdown structure, Testing and validation procedures
- Recommendations for detailed design

05 — Autonomous Robotic Tank Inspection System

Current inspection procedures for aircraft fuel tanks demand significant aircraft downtime and a myriad of resources. Long periods of venting required to rid the tank of hazardous fumes hinder prompt inspection by humans, which additionally render fuel tank inspections expensive and potentially harmful to personnel. The emergence of miniature flying robotics provides an opportunity to circumvent these slow and costly inspection practices, by virtue of significantly reducing the required venting time. Sustainability is paramount in this solution, most notably as the power usage for venting and human exposure to hazardous fumes is diminished considerably. Commissioned by Lockheed Martin, the autonomous robotic tank inspection system, or ARTIS, is a design solution proposed with the purpose of reducing the time and cost required for the inspection of aircraft fuel tanks.

The final design of ARTIS is presented in figure 1, in which each component is indicated for clarity. Highlights of the design include the following; A 15.2 Wh battery, allowing a total flight time of 10 minutes and 40 seconds. The propellers were designed to maximize flight efficiency within the given size constraints. Four cameras are used, two of which are used to provide 3D stereo-vision for navigation purposes, and two angled extra cameras for inspection purposes. Also used for navigation purposes are six laser range sensors. The autonomous flight is enabled by the application of visual-inertial odometry for navigation, an A* algorithm for guidance, and a cascaded controller loop to facilitate proper flight control and stability. The design includes two different densities of foam, which optimizes both mass usage and safety.

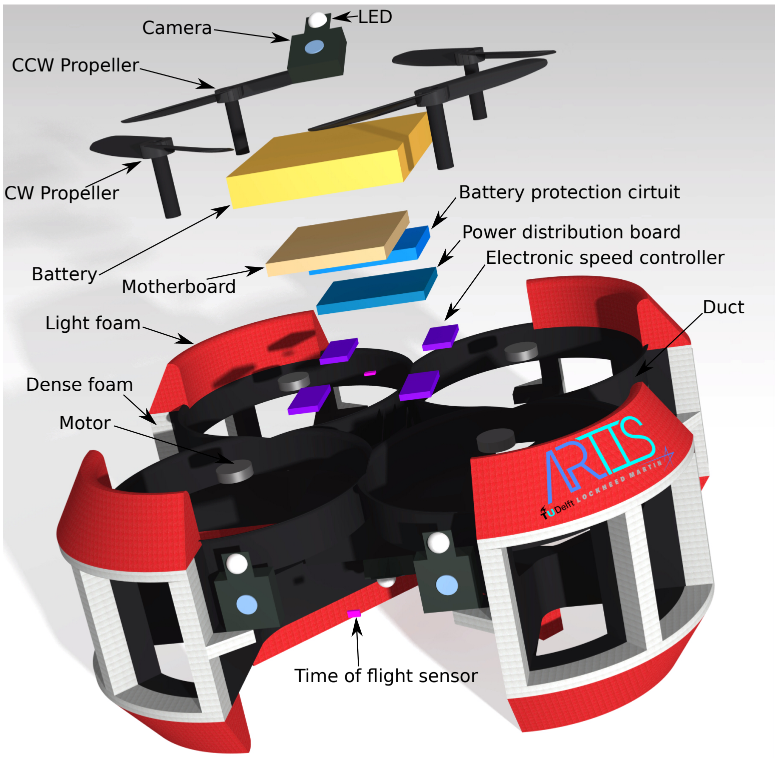


Figure 1: Annotated exploded view of ARTIS

Another significant challenge for this project was the spark prevention in the explosive tank environment. The spark prevention was done first of all by selecting brushless motors, which do not generate sparks. Second, all parts of the drone most prone to static charge, such as the ducts, are covered in aluminum foil to make them conductive. The propellers are also made of a conductive material. This conductive material can then dissipate any static charge generated.

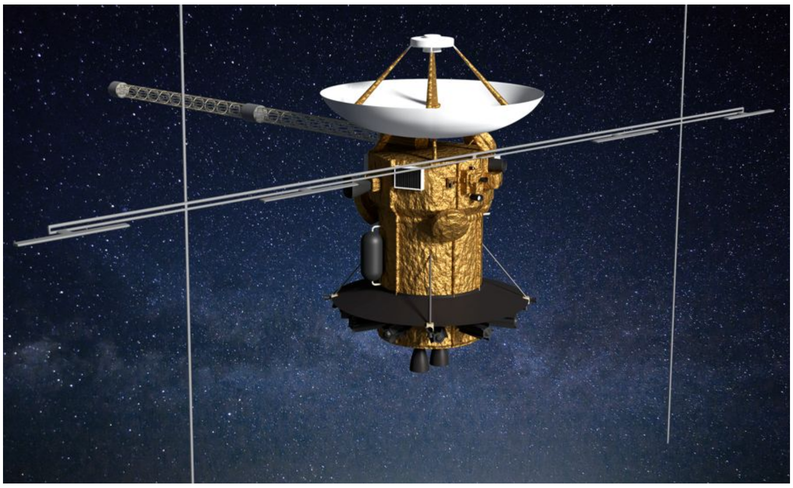
For the final weeks of design, the most significant activity is the generation of a simulation of the entire system, including a one-to-one copy of the algorithms to be used in the physical design. Granted sufficient time, this simulation will include sensor noise and disturbances like aerodynamic interference, due to proximity to the ceiling or walls. This simulation is very valuable in performing verification and validation activities. Furthermore, the team will try to 3D print an actual model to visualize the size of ARTIS as opposed to the tank, and so acquire additional insight in potential design improvements.

Group 06
20th June 2019

Returning to Saturn

The Returning to Saturn project is carried out by ten ambitious students over the course of eleven weeks with the aim to successfully design a spacecraft that can facilitate the performance of measurements to further characterise the Saturnian System, especially the moons Enceladus and Daphnis. Since the end of the Cassini mission in 2017 and its discovery of plumes, cryovolcanic eruptions of ionized water vapor, on Enceladus, the scientific community is eager to determine the possibility of life on the moon. By also studying the interaction of the shepherd moon Daphnis with the inner rings of Saturn, the group aims to gain a deeper understanding of the origins of our Solar System by studying the workings and composition of the Saturnian system. From this desire to know more, flows EPOSS: *Explorer of Plumes and Oceans in the Saturnian System.*

The EPOSS mission is characterised by a strong scientific yield, as the mission specifically targets the scientific community. By orbiting Enceladus, EPOSS answers questions that arose post the flybys performed by Cassini, regarding the composition of the moon. By flying through the plumes located on the south pole of the moon, EPOSS aims to collect and identify larger molecules, hopefully leading to the discovery of organisms in the extensive subcrustal-ocean. Other findings will be related to the overall geophysical composition of the moon and its role in the formation of Saturn's rings. By performing four Daphnis flybys, the team will also characterise the geophysical composition of the moon, but will especially collect solid particles while moving through Saturn's rings. This will bring to light the relationship between the moon and composition of the rings, and how Daphnis is responsible for the 'ripples' recorded by Cassini. This information combined with the comparability of the Saturnian System to the Solar System allows for a better explanation of the workings of the latter. The moon tour performed by the spacecraft in order to reach the bodies of interest, will give a unique opportunity to perform extra scientific measurements, for example by characterising the particles around the moon Rhea.



EPOSS is also characterised by innovation in its design. Considering the lack of sunlight on Saturn and the shortage in deep space power sources such as Plutonium, the team had to perform extensive research to find a solution to ensure optimal spacecraft functioning with these issues. This was found in the form of Americium RTGs, an innovative power source retrieved by processing nuclear waste and giving it new life. Not only is this incredibly innovative, but also gives a twist to the concept of nuclear power in terms of sustainability. Furthermore, regarding sustainability, thanks to EPOSS' light and compact design, the use of the fully reusable Falcon Heavy is possible. This will reduce the enormous waste, which is typical of launchers, by retrieval of all parts of the Falcon Heavy in order to implement them in future missions.

The EPOSS team hopes to see you at the symposium to hear more about our journey to Saturn.

Group 07 – Take Off and Landing of Commercial Aircraft Using Ground Based Power

June 20th, 2019

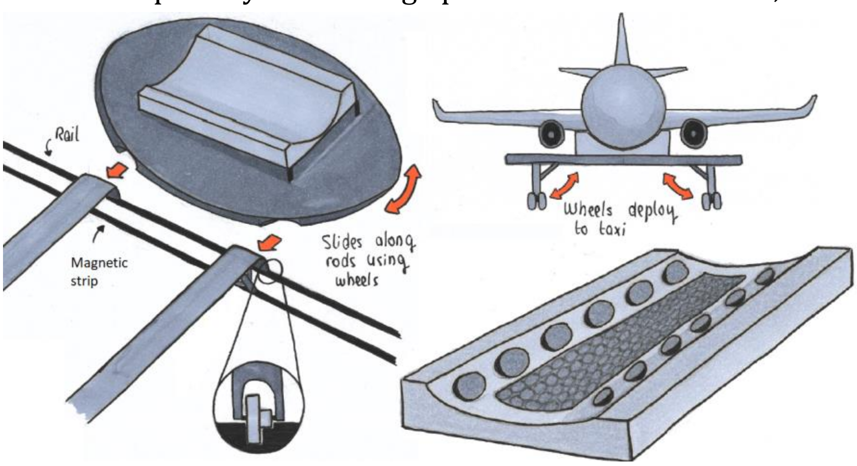
"A320 Family: Unbeatable fuel efficiency," a statement made by Airbus on their company website[1]. However, is it true that the performance of the Airbus A320 family cannot be optimised any further in terms of fuel consumption?

Currently, most aircraft use a conventional tricycle landing gear system in order to perform the take-off and landing procedure. The structural weight of this system is approximately 4% of the aircraft maximum take-off weight (MTOW). However, despite the significant weight contribution, the system is of no use during most parts of flight. Therefore, it is proposed to come up with a more sustainable solution to launch and recover commercial aircraft for short to medium range flights using ground based power. Due to the resulting weight reduction, fuel consumption will decrease as well. In addition, a ground based aircraft launching and recovering system allows for noise reduction in terms of sound exposure level.

The solution that is being proposed is called REMALS: Rails ElectroMagnetic Aircraft Launch System. It consists of a moving ground system on rails sunken into the runway, moved forward by electromagnetic propulsion. The aircraft is attached to a platform that allows for movement in six degrees of freedom to synchronise with the plane. Three harpoons are used to attach the aircraft to the platform, which are deployed using a combination of electrical and hydraulic actuators.

When using REMALS, the fuel consumption for a typical short range flight diminishes with at least 5% with respect to current aircraft. In addition, noise levels decrease with at least 4 SEL dB in the top 3 zip code areas where most complaints concerning aircraft noise are originating from in the area of Schiphol Airport. Besides, the current capacity of Schiphol can be maintained when using REMALS, while still allowing for conventional aircraft to use the runway in which the system is incorporated.

The future will have to point out how the implementation of the system should be tackled. Especially concerning up-front investment costs, it has to be determined to what extent stakeholders are willing to invest in a ground based powered system. However, its promising technical performance emphasises the potential of REMALS to contribute to a more sustainable future for the aviation industry.



[1] URL: https://www.airbus.com/aircraft/passenger-aircraft/a320-family.html [retrieved on June 19, 2019]

Jury Summary of Group 08
Demonstrator for Air-breathing Electrostatic Propulsion, Earth Observation Satellite

Aerospace engineering would not exist today if it were not for the unconventional thinkers along the way that questioned the boundary between what is possible and impossible. We thought it was impossible to fly with an object heavier than air, impossible to overcome the sound barrier, impossible to reuse rockets; we were proven wrong, not by an elaborate analysis or proof, but by demonstration. We want to demonstrate that it is possible to fly a spacecraft in an orbit lower than 250 km for 10 years, without loading a single gram of propellant.

RAMSES, the RAM Satellite for Earth Sensing, harvests more than 53 kilograms of atmospheric gases during its lifetime; it ionizes and accelerates the particles for sustained drag compensation. It will demonstrate not only the feasibility of air-breathing electrostatic propulsion, but also the commercial benefit of flying so close to Earth. While weighing less than 150 kg, RAMSES will perform imaging with a spatial resolution that is on par with currently operating spacecraft weighing more than 2.5 tons. This represents a significant step forward in the context of sustainability in spaceflight.

Breaking grounds is not easy. The spacecraft finds itself in a harsh operating environment, with high concentrations of atomic oxygen and large eclipse fractions. In addition to that, it will experience a full solar cycle over its lifetime. The atmosphere presents itself as both our friend and enemy at the same time: if the density becomes too low, the thruster will shut down. If it is too high or the spacecraft is not aligned with the flow, the drag will surpass the achievable thrust very quickly, which is already constrained by the abnormally high power requirements for a spacecraft of this class. Designing RAMSES has been about finding the sweet spot, about limiting the complexity as much as possible to keep the weight low and the reliability high.

This approach is implemented on all levels of the mission and spacecraft design. In order to avoid density fluctuations caused by variations in solar activity, RAMSES alters its orbital altitude to ‘surf’ the sinusoidal solar cycle. Maintaining a constant density allows for a passive intake design which delivers the required mass flow to the engine at all times. Alongside putting the first ever air intake in space, multipurpose fins are one of the most unique features of the spacecraft. They are deployed towards the back to overcome two of the most glaring challenges: maintaining attitude stability and providing a sufficiently large surface for the solar array with a minimal increase in drag.

Spaceflight is rapidly evolving and sustainability cannot be taken lightly. Marginal improvements will not be sufficient; it is time for a new approach. Collecting propellant in-situ is unheard of, and RAMSES will set the bar for future projects by challenging conventional methods.

Group 9 - A Personal Air Mobility Vehicle as a Maritime Pilot Shuttle (Loodswezen)

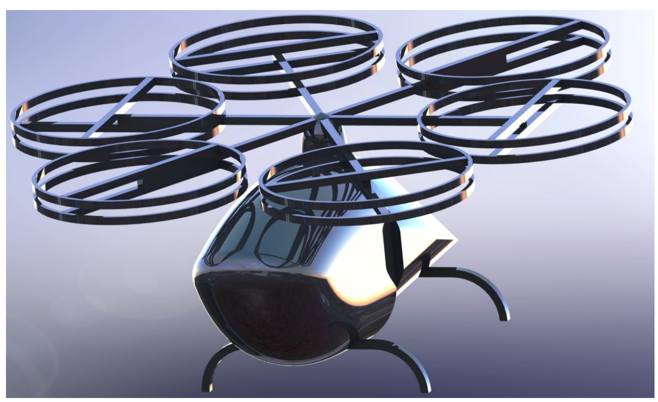
June 20th, 2019

Over the last eight weeks, Project Group 9 has been working on the design of a new vehicle to be used for maritime applications. PAMELA is a Personal Airborne Maritime ELectric and Autonomous pilot shuttle, the first of its kind in the industry. Its mission is to transport a maritime pilot in the harbour to and from ships in a new, cheaper, safer and more sustainable manner than anything in the market today.

The vehicle had to be capable of Vertical Take-Off and Landing, which made a multicopter concept more suitable for our mission. The vehicle had to fit on a 4 x 4 meters surface and be less than 2 meters tall, making it challenging to fit all the subsystems while keeping an aerodynamic profile as well as to design the necessary rotor size that could lift the vehicle. A trade-off had to be made between the use of a tricopter, a quadcopter and a hexacopter design which resulted in the hexacopter concept being chosen due to its lower power use, its additional redundancy and the availability of Commercial Off-The-Shelf engines on the market.

In order to generate sufficient lift, the hexacopter uses contra-rotating rotors. For the vehicle to be allowed to fly, it had to respect aeroacoustic regulations for noise emissions over harbour areas, and contra-rotating rotors are known to increase the noise levels. For this reason, as well as for the safety of the pilot, the use of ducts for the rotors was chosen.

Furthermore, appropriate cells capable of providing the vehicle with sufficient power had to be selected, which resulted in the use of 14 packs of lithium-ion batteries. This lead to having a flight range of more than 20 kilometers, fulfilling the requirement imposed by the customer. For improved stability, the rotors were positioned above the fuselage, adding extra ground clearance. It also allows for easy cabin access, enhancing the comfort of the passenger.



To necessarily package the subsystems and host the payload, minimum dimensions for the fuselage were settled. It was then possible to streamline the design of the fuselage into an aerodynamic profile in order to reduce the drag generated during flight. The materials for the structures of the vehicle were chosen to be a combination of an aluminium alloy substructure and a composite skin, creating a strong, lightweight and recyclable composition.

At the current phase, the technical design aspects of the vehicle are converging into one final design, and although the design is nearly finished, small details will be fixed in the coming two weeks before presenting the final design to the public.

Group #10 –StratoCruiser

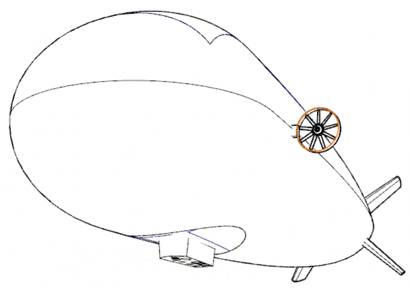
June 20th, 2019

Thermal infrared Earth observation is a form of imagery with applications in defense, environmental research, and disaster monitoring. At the moment, this imagery is predominantly acquired using satellites which are expensive and difficult to launch, operate, and maintain. Using a stratospheric balloon with space instrumentation for Earth observation provides a potentially cheaper and more accessible solution for obtaining imagery of the same quality. Therefore, the mission need of this project was to **design a thermal imaging Earth observation system which is cheaper and more maintainable than current Earth observation satellite systems**. System requirements were derived from the mission need statement as well as stakeholder requirements. At this stage, several conceptual designs were conceived by the group; these were differentiated by their lifting method (exclusively buoyancy vs. buoyancy and aerodynamics), lifting gas, instrumentation layout, etc. The performance of each concept was analyzed regarding aspects such as cost, complexity, and sustainability, allowing the group to conduct trade-offs between the options and choose one. This chosen concept, the StratoCruiser, is a partly autonomous hydrogen airship, reliant solely on buoyant lift, powered by solar energy and a regenerative fuel cell system. It accommodates a moving optical instrumentation system consisting of a primary mirror, noise-reducing baffle, and thermal infrared sensor.

At that point, the group began working in parallel on the preliminary design of the subsystems. These designs were presented along with the system concept at the Midterm Review. The following phase comprised of detailed design. This entailed using various software to simulate and optimize the subsystem. For example, the placement and area of the solar array had to be optimized. This was achieved using a discretized model of the surface of the airship in MATLAB and calculating the solar power received throughout the year. The best placement and size of the solar array was found such that the StratoCruiser can operate continuously regardless of the time of day or year. Another very important aspect of the operation of the StratoCruiser is how fast it can reach a point of interest in The Netherlands. The team analyzed stratospheric winds through the year to obtain the starting point(s) of an airship or a constellation of airships around the country to minimize the time to reach any location. This optimization was programmed in Python. Additionally, models of the airship were constructed in programs such as CATIA, Ansys, and Rhino to visualize the design and investigate its aerodynamic and structural performance.

With this multi-disciplinary analysis of the subsystems and operation of the StratoCruiser, the team worked to finalize a converged design that has several advantages over current satellite-based systems. The StratoCruiser is capable of operating an altitude of 20.5km continuously for 6 months without maintenance and capturing up to 80 pictures per minute of a point of interest with a resolution of 1.5m. Additionally, it can carry 300kg of other scientific payload. It can ascend to operational altitude or be brought down to the ground within hours. The StratoCruiser can achieve all this while being highly sustainable. It is reusable, its ascent and descent simply use controlled buoyancy and electrical propulsion, which is reliant on electricity sourced from solar energy. This energy can be directly used or stored for nights using electrolysis and then consumed via fuel cells, whose only exhaust is water. Satellites, on the other hand, require highly polluting rockets for launch. The StratoCruiser's lifting gas, hydrogen, is non-toxic and sustainably produced through electrolysis. The cooling systems used are closed-loop, so they do not release harmful chemicals into the environment. Although the cost is yet to be finalized, it is cheaper to launch and operate than satellites.

The StratoCruiser's accessible, sustainable, and affordable operation in comparison to satellites make it a very attractive option for scientific missions focusing on The Netherlands.



Initial drawing of the StratoCruiser

Group 11 – eVTOL Emergency Aircraft

June 20, 2019

The current ANWB emergency helicopter, the EC-135, is at risk of not being allowed to fly anymore due to the intense noise it makes. Our goal is to design a vertical take-off and landing emergency aircraft which will be able to reach a noise reduction of 25% compared to the current emergency helicopter. In addition to noise reduction, eliminating harmful emissions is of high importance. For this reason we designed an electric aircraft powered by a liquid hydrogen fuel cell.

It is a small aircraft flying at low speeds: the maximum wing span is nearly 15 meters and the cruise speed is 250 km/h at an altitude of 370 meters. This is achieved by an aircraft design which has partially integrated rotors in its wing for vertical take-off and landing, one separate rotor for cruise and a boom tail for stability. The cabin is designed for a maximum of five persons: one pilot, three passengers (including doctor and trained staff) and one patient. These follow directly from the requirements for the emergency aircraft as discussed with the ANWB emergency helicopter pilot based in Rotterdam.

We have developed a full-vehicle design, focusing on structures & materials, propulsion & electronics, stability & control and aerodynamics. In addition, an operations & logistics analysis is performed, where the day-to-day operations of an emergency aircraft is described as a whole. Moreover, a comprehensive cost analysis, risk management and contingency plans, production plan and interface definition analysis are made.
Since sustainability has been one of the main points of focus for our design, a life-time sustainability plan has been created. The aircraft has been designed to be as sustainable as possible, for social, economic and most importantly environmental sustainability.
Next to operating as an emergency helicopter, the final design can also replace other helicopters to contribute to a more sustainable world.

Group 12- Bigger is Better

June 19, 2019

As aviation keeps growing, so does the concern about the impact on the climate, local air quality and the noise generated by aircraft. Especially the way the aviation keeps growing is concerning; as found from a market analysis new aircraft tend to fly further than ever, while the passenger flows on short range routes keep increasing. This results in the aircraft being used far below their design specifications, which in turn leads to a suboptimal performance in terms of emissions and fuel consumption. The goal of this project was thus to develop a short range fixed wing aircraft capable of carrying 450 passengers which supports the growth of sustainable aviation. To drive the sustainability aspect of the aircraft, requirements regarding the fuel consumption, noise and cruise conditions were imposed. The fuel consumption namely had to be 10% less than current state of the art aircraft (B737-MAX and A320-NEO). Other requirements related to this project concerned the range, which was to be determined from the market analysis, operating costs, field performance and operational handling.

The first step taken in the design process was assessing how these requirements would drive the design. Initial budgets for the key design parameters were established before any design concepts were proposed. Once all requirements were established and analysed, a range of design concepts was established. This range originated from changing the key design parameters, like the cruise conditions and aspect ratio. Using tools developed by the team, the aerodynamics, structures, control & stability and the performance of the five most promising design concepts were assessed. The results of these analyses led were then used in a trade-off which resulted in a final design: Eco-hopper 450 with a double floor fuselage and a high strutted wing with ultra high bypass engines, see an artist impression in Figure 1.

Once the design layout was chosen, further analysis into the aerodynamic properties, sizing of the tail for controllability and stability, assessing the structural weight based on a structural analysis, and analyses into the compliance with the requirements were performed. This led to the conclusion that the Eco-hopper 450 performs significantly better from a sustainability point of view than any current state of the art aircraft. This was achieved by flying at a cruise altitude of 9 km with a cruise Mach number of 0.72. Upcoming weeks, these analyses will be expanded and more details about the design will emerge.

Figure 1 – Rendering of the Eco-hopper 450

Advanced Regional Aircraft – Group 13

Project Aquila – *"You cannot fly like an eagle with the wings of a mockingbird"*

The end of the Airbus A380 production proved a big point in the aviation industry: the hub-and-spoke system is becoming more and more obsolete. In the future, the demand for point-to-point transport will grow significantly. Considering intracontinental flights, flights between two remote airports are carried out by regional aircraft. However, the regional aircraft that are in operation today were built decades ago. Therefore, the mission for this project is to develop a new regional aircraft using innovative technologies which outperforms current competitors, especially in terms of sustainability. The aircraft was designed for a range of 1850 km, carrying 60 passengers.

Two innovations were implemented in this project, which are not certified yet on aircraft in use today. The first innovation was the use of a high aspect ratio, slender wing, to minimize lift-induced drag. Because of the slenderness, a carbon fibre reinforced polymer strut had to be introduced to ensure the structural integrity of the wing, and to optimise for weight. An airfoil shape was put around the strut, to minimise the loss of lift due to the interaction of the strut with the wing. The use of the latest generation of aluminium-lithium alloys was found to be optimal for the other structural components of the aircraft, both in terms of cost and producibility. No constraint on the slenderness of the wing was found yet, which is why the occurrence of flutter will be further investigated in the final weeks of this project.

The second innovation was the use of liquid natural gas (LNG) as fuel. The advantages of using LNG are that it produces less emissions and has a higher specific energy than jet fuel. Furthermore, LNG consists predominantly of methane, which can be produced carbon-neutrally, once this has shown to be cost effective. The challenges were found in designing and integrating cryotanks and designing new combustors to improve engine efficiency. It resulted in an increase in weight of the tanks with respect to conventional fuel tanks, although this challenge was overcome.

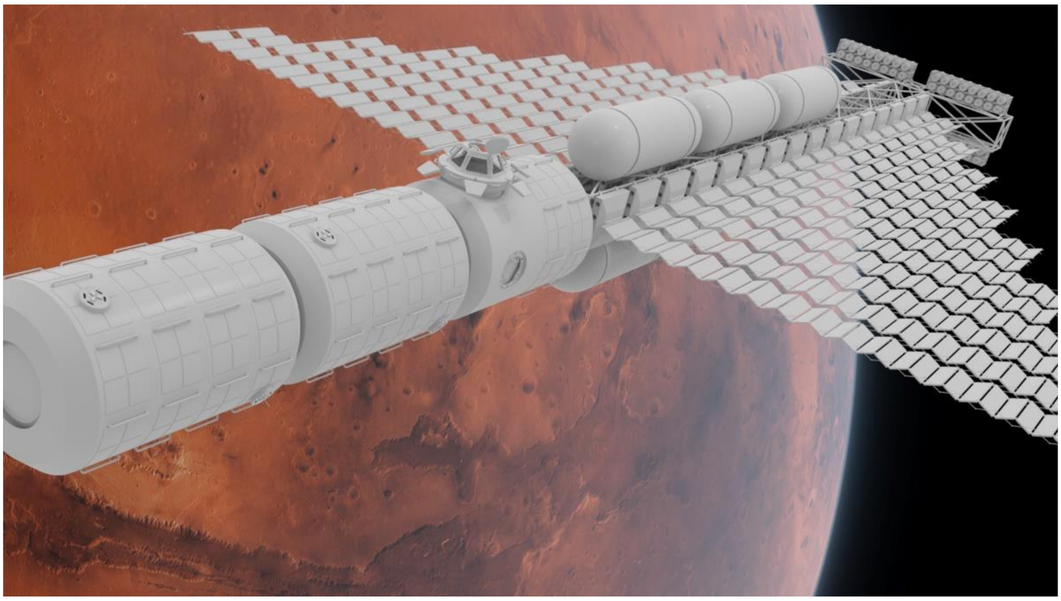
By being able to take off at a runway length of 1,213 m (at sea-level conditions), the aircraft is operable at both the smallest, regional airports as well as the bigger, international airports. Furthermore, the aircraft is implementable within 8 years, and 5-10 units can be produced per month to conquer the market. By entering the market with a retail price of 26.5 million USD, the Aquila is 2 million USD more expensive than the ATR72-600, the best in its class. However, in terms of sustainability the designed aircraft outperforms the ATR significantly. Compared to the ATR, the design resulted in a 36% reduction of CO_2 emission for a 1000 km trip. Additionally, the Aquila also has approximately 15% lower direct operational cost.

In summary, project Aquila shows exciting potential in filling the gap in regional transport and stimulating the further development of sustainable aviation.

For 10 weeks, DSE Group 14 has been working on the Delta Mars Project: designing a modular and reusable spacecraft to safely transport four astronauts with payload to Mars orbit and back by 2046. The result is a VASIMR electrothermal driven vehicle using argon propellant, fitted with 3 pressurised modules, and carrying enough supplies to sustain astronauts for over 1000 days in deep space. The spacecraft uses four low-enriched uranium fission reactors to generate 11 MW of electrical power, a delta shaped radiator design for thermal control, and resource recovery life support systems to regulate the cabin environment and supply the astronauts with water and oxygen. The spacecraft is capable of multiple mission profiles, including carrying a lander for descent to the Martian surface.

Elements considered during the design have been the shielding of astronauts from deep space radiation, protection from micro-meteorite impacts, in orbit assembly, launcher packing, physiological and psychological wellbeing of astronauts, attitude determination and control, communication, command and data handling, as well as low thrust transfer determination and electrical power system design. All of these considerations have been integrated into a coherent design using a structured systems engineering approach. Operation of the spacecraft in the mission phases of assembly, transfer to mars, and resupply have also been considered. The project features a cohesive business plan in order to be financially viable. Technical risks have been identified, assessed, and where possible, mitigated. Additionally, the sustainability of the project has been evaluated by considering environmental risks and conducting a life cycle assessment.

In 2046 the assembled spacecraft will begin a spiral escape trajectory from Earth orbit. Once it has passed the Van-Allen belts, a crew capsule fitted with high thrust chemical engines will rendezvous with the spacecraft, boarding the astronauts. Following a system check, the spacecraft will initiate a low thrust trajectory towards Mars interception. It will insert into low Martian orbit, where it will remain for approximately 300 days. Following Martian stay, it will initiate transfer back to Earth. The astronauts will return to Earth surface using a crew capsule, and the spacecraft will remain in orbit where it will undergo inspection, maintenance, and resupply for following missions to Mars.

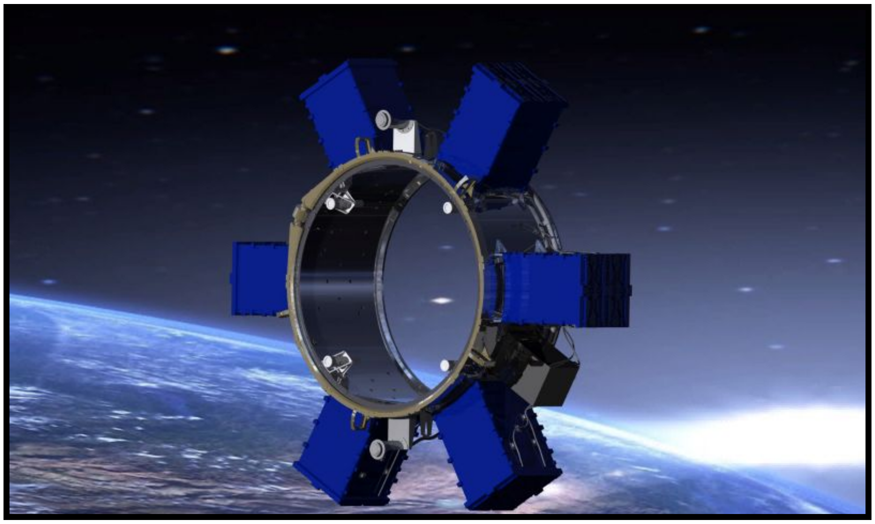


DSE Group 14
Transfer to Mars and Back in the Next Two Decades
TU Delft Faculty of Aerospace Engineering
2019

Group 15: SPS-2 Free-Flyer

Competitive European nanosat and microsat launch facility

In a growing Space sector and a rapidly changing world, small satellites are set to be the future of in-orbit science missions. The objective of the group is to design a competitive European small satellite deployment and support platform that will act as a support structure for the main payload of the Arianespace Vega-C rockets. We hereby proudly present the pinnacle in small satellite support and deployment platforms: the SPS-2 Free-Flyer.



The first iteration of this concept, the SPS-1 (Secondary Payload Structure) is a payload carrier designed for the Vega-C with the capability to be a small satellite deployment platform, with integrated bays for CubeSats. Together with Airbus Defence and Space, Group 15 has worked to make this platform a free-flying satellite in its own right, and thus the SPS-2 Free-Flyer was born. In order to assist Airbus as much as possible, the design was worked out to the greatest degree of realism possible throughout the entire design phase. Instead of requiring an entire satellite design to use their instrument for important scientific measurement, customers can use the SPS-2 FF to power, stabilise and support a more demanding wide range of third-party payload at the lowest cost possible. This allows for organisations such as the European Space Agency to focus on their instruments, while the SPS-2 FF provides all necessary support. For these reasons, the SPS can become a truly revolutionary platform, as it will be offering features that no other deployment system on the market will be able to provide.

The SPS-2 FF is expected to operate in an 850 by 350 km sun-synchronous orbit, supporting a payload of up to 50 kg in mass and a power requirement of 100 W. In terms of sizing, it has an internal diameter of approximately 0.95 meters and a height of 0.45 meters. This concept is sustainable by design: the purpose of it is to utilise space in the Vega that would not be used otherwise, thus lowering cost and maximizing the amount of payload in space without supplementary launch equipment.

The group has worked on the complete conceptual design of the SPS for the entire duration of the project and has designed all subsystems, analysed costs, risk and sustainability to assist Airbus in the design of the SPS-2 FF. Several concepts were traded off and the concept in the image above was selected for its robustness in these trade-offs.

In addition to this layout, Group 15 has designed an attitude determination and control subsystem, power subsystem, analysed all operations the spacecraft will need to perform in orbit and analysed the thermal and structural properties of the spacecraft. Leading to completely designed subsystems for the spacecraft..

The group is eager to share the details of the DSE progress with the Jury, the Mentors, the TAs and all OSCC members, and looks forward to seeing you at the Symposium.

GROUP 16 – Door2Door

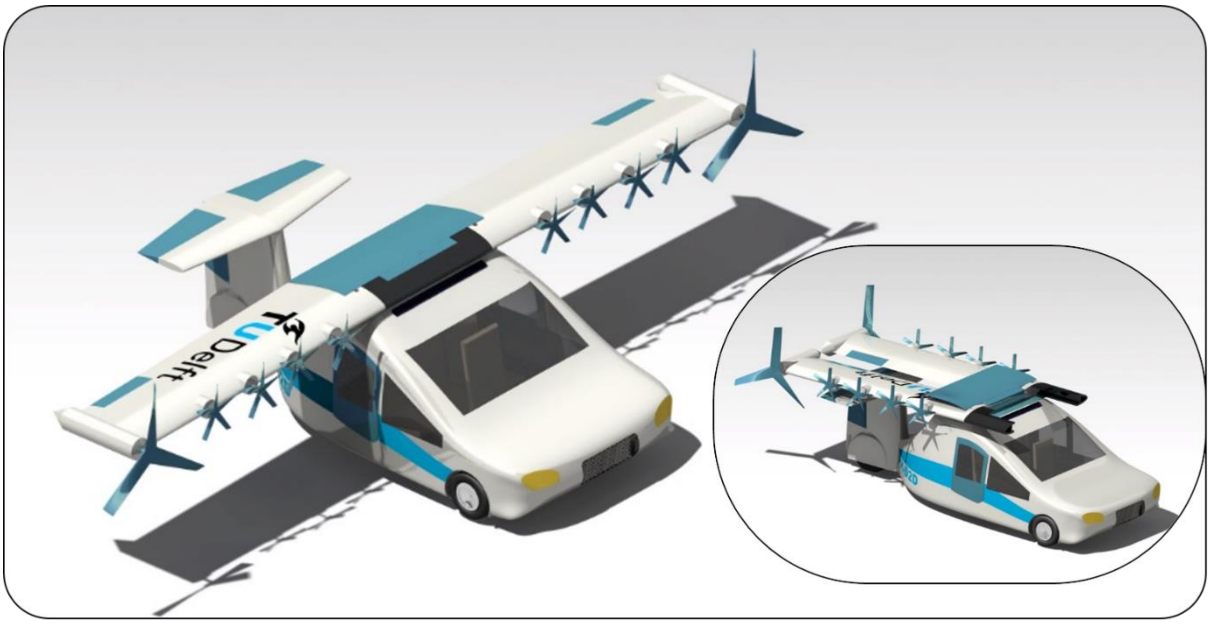
June 20, 2019

Billions of people travel by car every day, yet by doing so, they are not only contributing to the queues of traffic which congest our roads, but to the damaging greenhouse gasses which pollute our cities. What if you could step out of your door, into your vehicle, drive to an airfield and take off, simultaneously avoiding all the traffic on the roads and the release of harmful emissions? That's where the Door2Door vehicle comes in. Our mission is to design the world's first green personal air vehicle, capable of carrying up to 4 passengers whilst only releasing water as a by-product. After months of research and hard work, we are proud to present the 'Door2Door HAVIC- Hydrogen Aerial Vehicle for Intercity Commuting'. The 1.6 tonne HAVIC is a versatile vehicle which is capable of driving on the roads like a normal car before extending its 8.8m wide wings and flying for up to 400km. The vehicle has space for 4 passengers and can carry up to 360kg of payload at a max speed of 250km/h.

The HAVIC has several unique design features that have been researched and developed to maximise its performance. The vehicle is powered by hydrogen fuel cells which can convert liquid hydrogen stored in a cryogenic tank to electrical power with only water as an emission. This electrical power feeds two large wing tip motors, as well as eight high-lift propellers distributed along the wingspan. The latter enable the HAVIC to reach an effective C_L of over 4.0 and greatly improve take-off efficiency. The three-wheeled configuration allows for a better airflow around the vehicle body and this is also aided by a completely revolutionary 'arc-duct' which takes high energy air from the front of the vehicle and guides it to the back, allowing the boundary layer to be re-energised and delaying separation. The wings and wing-box, as well as the space frame, suspension, and drivetrain have all been designed from the ground up over the past eight weeks and all the forces, stresses, and deflections have been modelled to ensure structural integrity and safety.

During the design process, the team has also considered the risk, sustainability, and financial aspect of the HAVIC. The vehicle has been optimized to ensure redundancy and compliance with UN agenda points. It could operate using only existing infrastructure at first, and plans for expansion have been elaborated upon. For the final presentation, the unique points of the design will be expanded upon and a high level technical report will be produced.

Group 16 truly believes, that with the Door2Door HAVIC they have found a solution to sustainable and versatile personal travel.



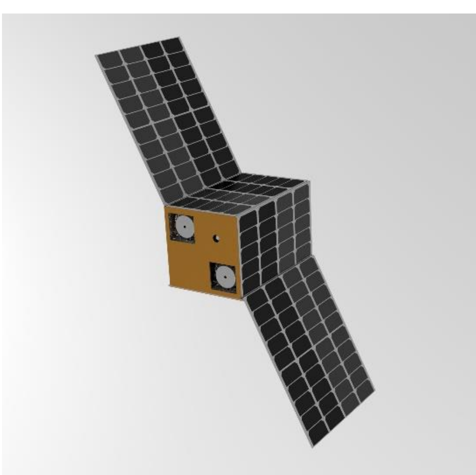
VLEO CubeSat Design for Earth Observation-Group 17

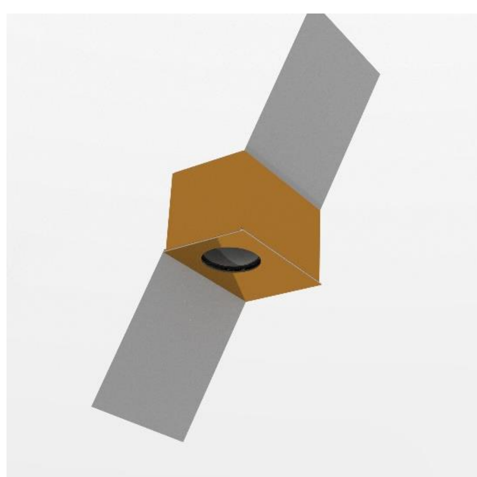
June 20th, 2019

The field of Earth Observation is growing drastically, with applications spanning across commercial, civil government and defense sectors. Notably, tackling the colossal climate change is facilitated through use of satellite imagery: Brazil's government, for example, actively employs this data to monitor and assess forest damage caused by illegal logging, fires or natural degradation in the Amazonian rainforest, an otherwise impossible task due to the territory's vastness. And whilst certain platforms offering sub-meter resolution imagery, efforts are undertaken to push for higher revisit times of key areas. CubeSats are a perfect candidate to approach this mission, due to their low-cost standardized structure hinting at the construction of a space constellation. Planet Corp, an American satellite company, has attempted this challenge in 2013 by launching over 130 CubeSats actively mapping the Earth at 4m resolution with a daily refresh rate. Our goal is to outperform this platform with regards to spatial and temporal resolution, using the strategy of flying in VLEO (Very Low Earth Orbit), incorporating an innovative propulsion system and applying super-resolution software to enhance image quality. Emphasis is placed on extending orbit lifetime to reduce manufacturing costs, ultimately resulting in the most competitive platform.

The team has conducted a market analysis to identify a direction for product development coupled with an extensive literature study for all relevant satellite subsystems: this allowed to generate various concepts to face the mission. These were evaluated in a multivariate trade-off, eventually converging to a 2x2x3 unit configuration named the Sat-ELITE (Extended Lifetime Innovative TEchnology): this features an ample camera aperture, two electrostatic engines and three-axis active attitude control. A constellation of 202 CubeSats shall be distributed along two different planes, starring mirrored solar panels to maximise the power influx in a Sun-Synchronous Orbit. This will allow mapping of 99% of Earth's surface at a twice-daily revisit rate.

In the coming weeks, the team is planning to build upon the integration of all subsystems into one coherent design, improving system reliability by identifying and assessing single point failures. The methods used for design will be validated through analytical models and tests. Finally, the business' plan of action is drafted to outline all activities needed to launch the constellation in the skies.





Group 18 - Sustainable Urban Air Mobility System

June 20, 2019

Due to the ever-increasing congestion and demand for transport within cities, new solutions for transport systems have to be explored. With ground and underground based transport modes reaching their maximum capacity, a shift towards air-based city transport is made with the so called electric Vertical Take-off and Landing (eVTOL) aircraft. However, large challenges like noise, air traffic management and charging facilities for the vehicles have to be tackled. Commissioned by EmbraerX, an Urban Air Mobility System for 2050 is designed that will create a sustainable alternative to existing transport and reduce road congestion.

A four-person tilt-wing aircraft is designed (Figure 1), equipped with four electrically driven propellers on the wings and two smaller ones on the canard. Having the advantages of a helicopter during take-off and the efficiency of an aircraft during cruise it is the best of both worlds. For our chosen "pilot city" Los Angeles (LA), the vehicle is designed for a range up to 60 km, to serve the heavily congested commuter routes. The electric propulsion will result in no local emissions and with quick charging at the gate, fast turnaround times are possible.

The scheduling minimises the amount of flights without passengers and makes sure the waiting times at the gate are reduced. For the infrastructure, an example of a vertiport implemented on an existing building in the centre of LA is designed. This provides a baseline of a vertiport design that can easily be implemented on other existing buildings, without large adaptations. The vertiports are connected to existing public transport modes to integrate the UAM in a multimodal transport system.

At the moment of writing this summary, the preliminary design is finished, but in the next week iterations on battery mass and structural weight will be performed. The vehicle will be optimised for a low energy use and noise, to keep it not only environmentally sustainable but also socially acceptable. Furthermore, a more thorough cost and profit prediction will be made and the reliability, maintainability and manufacturing will be studied.
The team is looking forward to present the complete Urban Air Mobility system during the symposium at the 4th of July.

Figure 1: Four-person tilt wing aircraft designed for an Urban Air Mobility System

Futura

Group 19

The objective of the project is to design a fully sustainable hydrogen powered rotor-craft with vertical take-off and landing capabilities. The aircraft, having a maximum take off weight of 4000 kg, is going to provide quick transport from airports hubs having no emission except water. The outcome of the conceptual design phase is a tilt rotor aircraft which can reach a maximum speed of 400 km/h and a maximum range of 300 km being powered by an hydrogen electric power plant system.

After an initial design phase in which different configurations were explored and different power plant systems were considered, the design of tilt-rotor aircraft was brought forward. Futura's innovation is based on three pillars: a novel power plant system based on a PEM fuel cell, an optimized aerodynamic design which introduces a lifting body fuselage and an integral sustainable development philosophy which encompasses all the aircraft's systems.

The team obtained a conceptual design of the aircraft whose sustainability details will be further analyzed in the final phase. This will provide a complete picture of why the aircraft's sustainability is the heart core of the design mission.

Group 21 - Design of a secondary rotor wind turbine

June 20th, 2019

Project mission: To explore the possibilities of an innovative new wind turbine design, using horizontal axis secondary rotors attached to a vertical axis primary rotor.

Over the past weeks, our team has worked on the development of a secondary rotor vertical axis wind turbine (SRVAWT) which has a rated power of 10 MW at a rated velocity of 11 m/s, and which is intended for offshore operation. This concept was first proposed by the University of Strathclyde but has not been analyzed in detail before.

The design consists of a 182-meter diameter, X-shaped vertical axis primary rotor, which does not generate electric power itself but which serves to convert kinetic energy from the wind into rotational motion. As a consequence, the two 24-meter diameter, power generating secondary rotors attached to the tips of its bottom blades face incoming velocities not seen in conventional turbines. The resulting rotational velocities of these rotors make it possible to eliminate a gearbox in their drivetrains, while still keeping the generators at a reasonable size.

The resulting direct-drive configuration is expected to provide power at a lower cost of energy, with equivalent or higher reliability when compared to conventional horizontal axis wind turbines of similar rated power. Other design objectives include a reduction in weight, more specifically a reduction in drivetrain weight when compared to conventional turbines, as well as an improved sustainability strategy. The turbine design is shown in figure 1.

At the time of writing this summary, our team is in the process of finalizing the structural and aerodynamic analysis of the design, as well as its control strategy. In addition, the turbine is being analysed on its RAMS characteristics, technical risk and cost of energy. All results and the final design will be presented during the Symposium on July 4th.

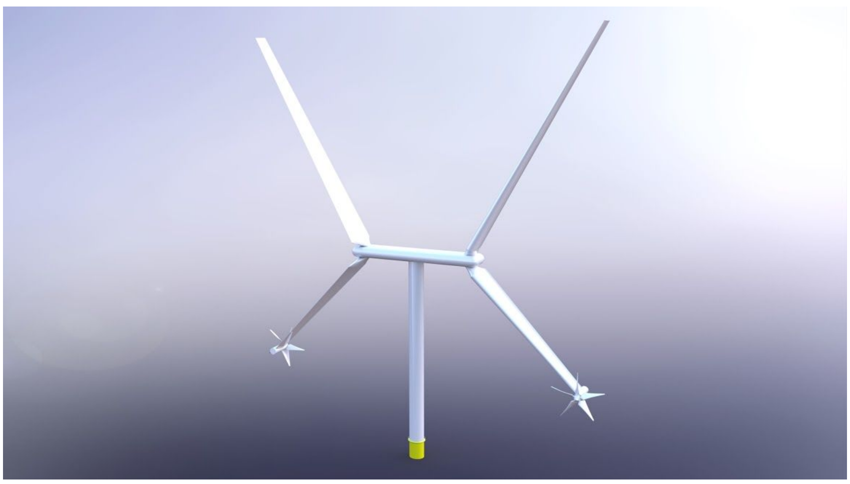


Figure 1 - The SRVAWT design

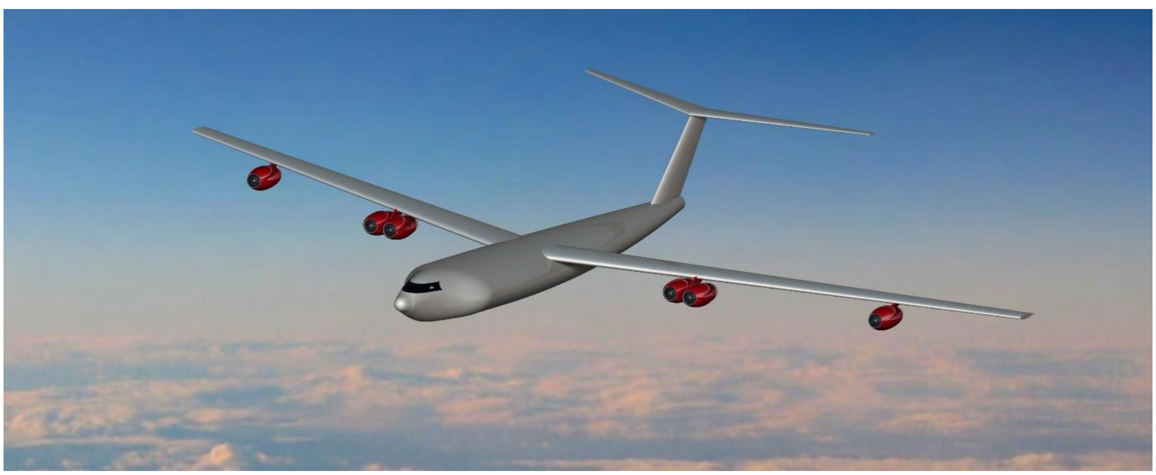
Group 22 – Low-cost System for Stratospheric Aerosol Injection

The greatest challenge that faces humanity is the one of global warming. The objective which once was to limit the global warming to below 1.5ºC now appears to no longer be achievable due to the ever-increasing greenhouse gas emissions. It may be necessary to employ emergency measures to prevent excessive warming of the Earth and a possible measure to actively counteract this is stratospheric aerosol injection. This is Group 22's take on providing an emergency measure for global warming. The mission aims to design a system, referred to as ***Ceres***, capable of delivering 3Tg of SO_2 at an altitude of 20km by means of an active fleet of aircraft.

A trade-off was performed on the concept of the aircraft and it was established that a conventional subsonic configuration was the most feasible for the mission. One of the main challenges encountered in the design of the fleet was the limitation of the design space at high-altitude cruise and dispersal. To further prove the feasibility of the concept and to ensure that the concept complies with the requirements, a thorough analysis was conducted on the different subgroups for the aircraft such as, but not limited to, the aerodynamics, propulsions, stability & control, and structural design. The current external layout of the Ceres aircraft is visualised in the figure below.

The project also focuses on providing a sustainable and cost-effective design, hence, an extensive cost analysis and a secondary environmental impact assessment were conducted for Ceres to quantify the cost financially and environmentally. These analyses are critical for the mission to ensure that the development of the system will not result in a positive net contribution to global warming. Furthermore, low cost is favourable in case the Ceres mission must come to an abrupt stop.

With the final deadline approaching, the main design phase of the Ceres system will be completed as well as the design integration of Ceres in society. This will include the further recommendations of the mission and the post-DSE planning of the project.



Group #23 – Adaptive Regional Airliner

June 20, 2019

Modern aircraft are typically designed for a certain design point, that is defined in terms of passenger capacity and range. This makes these aircraft optimal and very efficient for a particular flight profile, but overdesigned for or incapable of flying other profiles. Aircraft manufacturers therefore design a family of aircraft, to be able to meet the varying needs of airlines. The aim of this design project is to design a single avant-garde aircraft, one that is capable of adapting to serve a number of design points, in order to accommodate changing passenger demand. That is why the mission need statement of the project is to **design an adaptive regional airliner capable of meeting a variety of operational profiles with a short conversion time**. From the mission need statement, requirements were established, along with a number of stakeholder requirements that were stipulated by the customer. Thorough market and requirement analyses were performed, and three design points were chosen, reflecting a market gap, that would make the aircraft competitive. The three design points are: 90 passengers at 4000 km, 120 passengers at 2000 km, and 120 passengers at 4000 km. With the requirements set, it was possible to begin creating conceptual ideas. A number of strawman concepts were generated by all team members, and a design option tree was constructed, which helped in the elimination of several non-feasible concepts. Finally, three full concepts were chosen to enter a trade-off. Each technical discipline group set their own criteria to compare the concepts, based on the requirements. The trade-off was performed, and one concept was finally chosen. The chosen concept relies on having a separate fuselage section that is attached to the fuselage, behind the nose, to increase the available passenger capacity. As the extension of the fuselage would cause a forward center of gravity shift, as well as requiring more lift from the wings, a canard is fixed to the removable fuselage section to aid with those challenges. The final phase of the project aimed to have a more detailed design of the aircraft. This was done by having every discipline model their design process in Python, which was later compiled into a single program which is able to iterate, in order to manage the interfaces and converge to single values. The design of the aircraft faced some new challenges, due to its adaptability feature. A special joining method was designed specifically for the aircraft, as well as an alignment system, that uses lasers and works in a feedback loop with the lifts to accurately position the detachable sections. This resulted in a mostly automated system that is able to meet and outdo the requirement of an 8-hour conversion time, and is able to complete the conversion in 4.5 hours. As mentioned before, the designed aircraft should perform as well as a conventional aircraft in all design points. However, the group was more ambitious, and is determined to make the adaptive regional airliner more efficient and sustainable than competition. Three main sustainability aspects were analyzed: noise, CO_2, and NO_x emissions. The aircraft is able to reduce noise emissions upon approach and take-off, by using a cutting-edge engine and implementing airframe noise reduction measures. For reducing CO_2 and NO_x emissions, electrical taxiing was used. Additionally, the aircraft weight was decreased through the use of state-of-the-art materials such as carbon fiber and aluminium aramid fibers throughout a significant part of the aircraft, in order to further reduce fuel consumption. This resulted in a reduction of 38% in CO_2 emissions compared to the Embraer E1 family, and a reduction in NO_x emissions of approximately 50% compared to the CAEP/6 regulation.