Annual Report 2021/2022

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“Contribute to the Advancement of Life and Take Part in Exploring its Origins by Developing Systems Meant for Space”

- The ARIS Vision

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Official annual report of ARIS for the fiscal year from October 2021 to October 2022

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2022 – Reaching for the Stars

EXECUTIVE SUMMARY

In September 2021, ARIS started into its most ambitious year yet. By then, more than 300 motivated students tackled challenges in the field of rocket, engine, satellite and autonomous vehicle engineering. This diversification in the project portfolio also motivated – in fact required – significant improvements to various process flows throughout the organisation.

Despite formulating an extremely ambitious project plan for the cycle of 2021/2022, our teams met – or many times exceeded – everyone's expectations. At its third participation at SAC in June 2022 in New Mexico, ARIS entered in the highest category possible – the SRAD 30'000ft category. After the first ever launch of a sounding rocket propelled by an ARIS-developed HRE only months earlier, the teams HELVETIA and ASTREA could yet improve on the system, culminating in ARIS' first launch to – and fully successful recovery from – a height of more than 10'000 m.

October 2022 was a busy – and momentous – month for our association. We started off with a zero-g test flight of our satellite. The goal of our research driven project SAGE is to operate a platform capable of creating a milligravity environment and perform experiments on a biological payload in orbit. This zero-g test being the first of its kind in our organisation's history required a new level of preparation. During its three flights the team could gather many valuable data on all three conducted experiments.

In the same month and after removing all obstacles, ARIS celebrated another first – the first firing of a bi-liquid engine. With their test system project LEA laid the foundation for the platform that shall propel ARIS to space within the coming decade.

Building up on the predecessor project, our guided recovery system was pushed to the next level as well. With the first integration of such a system into a fully functional sounding rocket, project PERIPHAS aimed at pushing this technology from an impressive demonstrator to flight proven hardware. This goal was met at this years edition of EuRoC in Portugal, where the system was first launched to 3000m – with a deviation of less than 2%, thanks to the previously developed air break system – and then tested during a 10 minute long autonomously guided descent.

Our second research focussed project NAUTILUS set itself the goal to develop an autonomous under water vehicle. In the far future, such a technology could be used to search the vast oceans of icy moons in our solar system for traces of life. On a shorter timescale, the team aims at contributing to the understanding of the impact of global warming by studying the waters under the arctic ice shield. By October 2022 the team had all parts of the system ready and was getting ready for its first full-system test.

With the successful completion of ARIS' previous five year timeline on the horizon, in 2022 it was time to redefine ARIS' goals for the coming decade. Including the input of many of our members, the goals for the coming decade of our association were reformulated, goals that shall propel ARIS into orbit within ten years. While the timeline we ideated certainly is challenging – especially tackling it in the scope of a student organisation – our past achievements show: provided proper framework our members can achieve feats that are hard to imagine possible.

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1. ARIS Report of Activities in 2021/2022

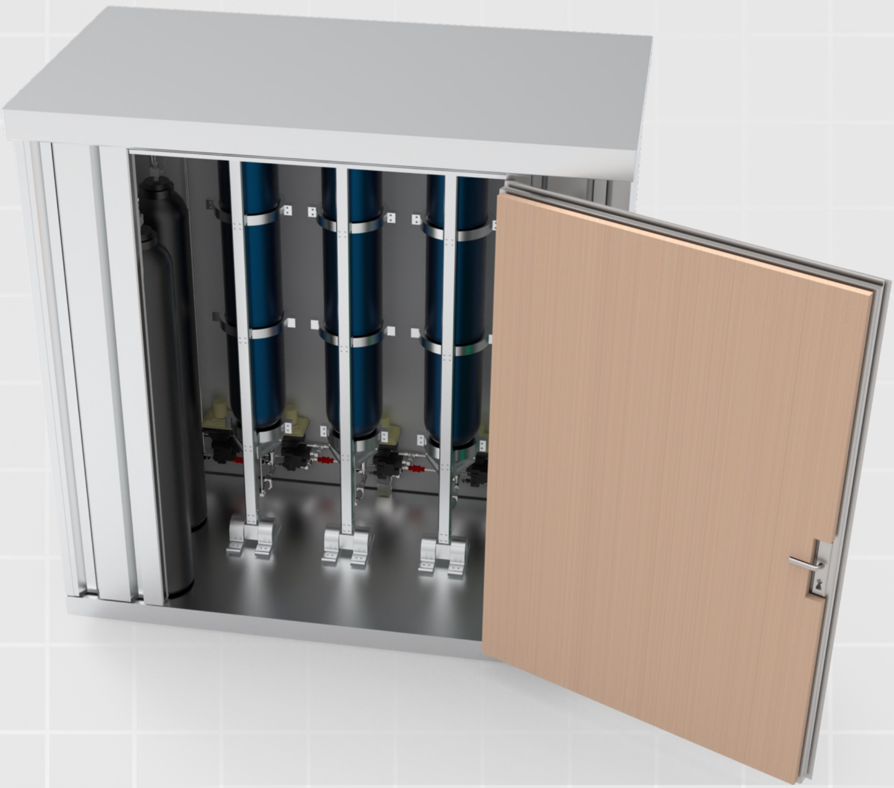
1.1 Project ASTREA

Project ASTREA set out to develop the fourth generation hybrid rocket engine at ARIS. The team consisted of eight mechanical engineering students in the final year of their Bachelor’s degree at ETH and was conducted as a Focus Project, meaning that the project contributes towards the official studies of the team. The project was supervised by Professor Lino Guzzella, and the team was also supported by coaches and technical advisors from previous engine teams at ARIS, as well as Mr. Bruno Berger, founder of the Swiss Propulsion Laboratory. The main goals were clear from the beginning: to integrate the ASTREA engine into the HELVETIA rocket, and to compete at and win the 2022 Spaceport America Cup in New Mexico, USA.

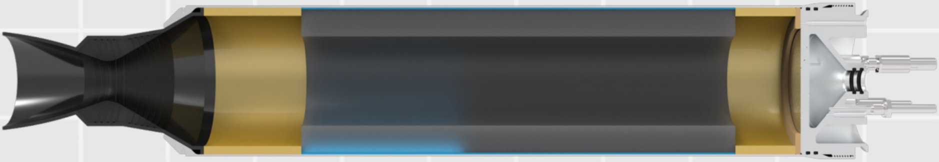
First Team Picture of Project ASTREA.

The project kicked off in September 2021 with the start of the new fall semester. The first milestone came just two weeks into the project in the form of the System Definition Review. After this, the project moved into the divergent design phase. Here, the team took a deep dive into hybrid rocket engine theory and reviewed past ARIS HRE designs. The team was encouraged to come up with creative solutions and ultimately decided to pursue an aerospike nozzle design, as well as to redesign the remote filling station. The aerospike presented many challenging technical hurdles to overcome and accompanied the team to their next milestone in early November, the Preliminary Design Review. Here, the various designs of the engine and filling station were presented, and much valuable feedback was received. Ultimately, the aerospike nozzle design proved to be too large of a hurdle to overcome and the idea was scrapped in favor of a traditional de Laval nozzle design.

With the conclusion of the preliminary design phase, the team officially entered the convergent design phase wherein a final design of the engine filling station was to be chosen and refined. Furthermore, much work was done on the sponsoring and project supporters front in finding suppliers and manufacturers for the ASTREA engine. The last major milestone for the first semester was the Critical Design Review in early December. Once again, very valuable feedback on what was to become the final configuration was received, and the team got back to work implementing feedback and inching ever closer to the final ASTREA designs. This work continued until late December when the team shifted their focus from rocket engines to passing exams, as well as writing their intermediate report.



CAD render of the remote filling station.

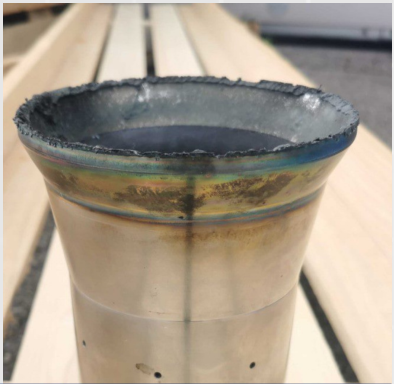


Cross section of the ASTREA flight combustion chamber.

The bulk of the manufacturing took place over the semester break and when the team regrouped in February, they were very eager to kick off the exciting testing phase of the project! Many days were spent at the team's testing site at Ochsenboden in the beautiful Swiss mountains conducting preparatory tasks and tests. The remote filling station was assembled, modifications to the test stand were conducted, and various qualification tests on the system were passed. Unfortunately, manufacturing delays and unforeseen assembly issues started to eat into the testing campaign timeline and valuable buffer days were being lost.

Team picture in front of test firing container in Ochsenboden.

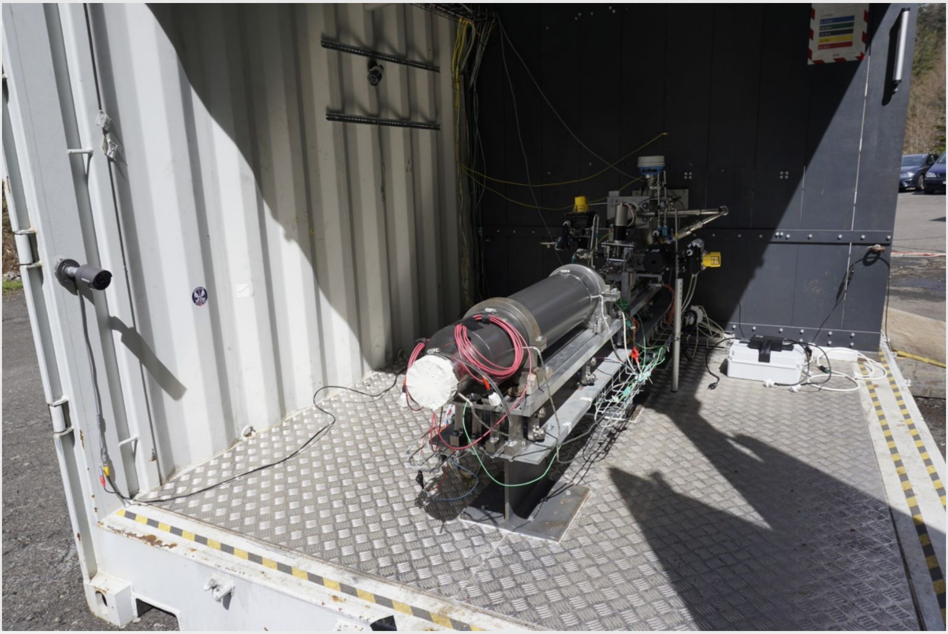
After many adjustments to the system and the timeline, the team was finally ready for last review before major full system tests could be conducted, the Readiness Review. Upon the successful completion of this, the first cold flow test was conducted in mid March. In total six cold flow tests were performed to validate various elements of the design. During the cold flow campaign, some issues were encountered, including various leakages, and unexpected mass flow behavior. These issues were dealt with through small design changes, as well as adjustments made to the testing timeline.



Team in their office space at the ARIS Hub in Dübendorf and the melted test nozzle.

Upon completion of the extensive cold flow campaign, the team was ready to move into the most critical phase of the testing campaign, the static firings. The first attempts were unfortunately marred by further leakages in the filling system, as well as two failed ignitions. An extensive root cause analysis of the ignition failures was conducted, and the leakages in the system were eventually snuffed out. The remote filling system was constantly being improved, and eventually the team was able to complete their entire filling process in just eight minutes. Then, finally, on April 29th at 15:24 team ASTREA conducted their first static firing. The preparation went smoothly, the filling worked flawlessly, and the ignition was spectacular. The team was buzzing with excitement and their hard work was starting to pay off! But all was not well. Upon engine disassembly that evening it was discovered that the test nozzle, which was intended as a multi-use part, had melted at a critical interface. This was a sobering revelation, and it instantly brought the team back down from the high that they experienced mere hours ago.

After determining the cause of the failure and debating possible paths forward, the team decided it best to switch from using the test setup to the flight setup far earlier than was intended in the testing campaign. The testing timeline was once again readjusted with certain planned tests now being scrapped. Furthermore, crucial integration tests with HELVETIA were being delayed further and further. Nonetheless, the team pushed on and was ready for their next static firing test using the aforementioned flight setup, on May 6th. Once again, the preparation went smoothly, filling was concluded, and the ASTREA engine was again ready to fire. Unfortunately, due to a small error in the assembly process, the oxygen ignition tube was ejected from the combustion chamber prematurely and the firing failed. Disappointed, but ever determined, the team returned to Dübendorf and quickly overhauled the engine and were once again ready for their next attempt on May 7th.



Combustion chamber in the test-configuration shortly before the first firing.

Preconditions completed, filling completed, and the test conductor finally says: “you may fire when ready.” The team holds their breath as the oxygen is pumped into the combustion chamber once again, and the high voltage lines initiate a spark at the upstream end of the chamber. The ignition flame spits out of the nozzle for six seconds, and then the main valve is opened. Instantly 2.5kg/s of nitrous oxide rush into the chamber and for the second time the ASTREA engine roars to life! Then as quickly as it started, it was over. The test container electronics had initiated an auto abort sequence and it soon became evident that something was very wrong. As the team checked the surveillance streams and looked out the bunker windows at the test bench, flames were spotted where there should be none. A catastrophic engine burn through had occurred in the pre-combustion chamber. Quickly, the team remotely purged the lines with nitrogen to extinguish the flames.

Test firing resulting in an engine burn through in the precombustion chamber.

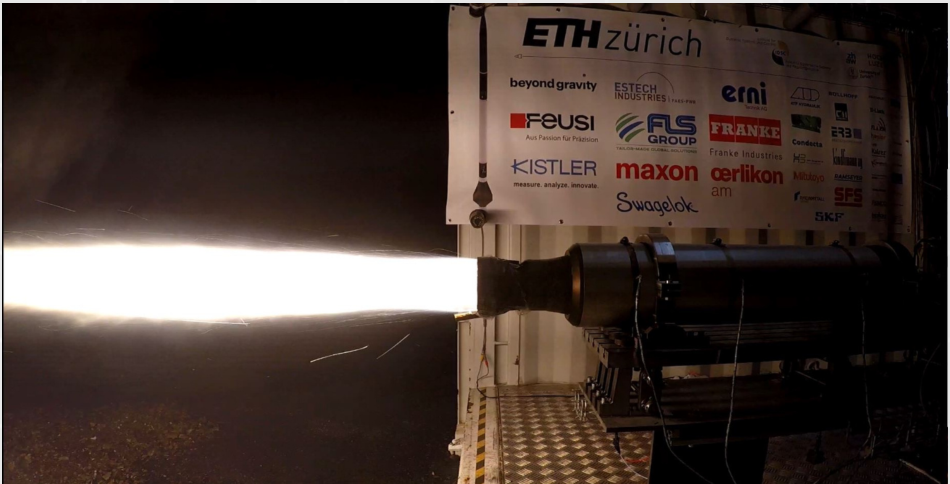
Everyone was devastated. This was the ultimate low point in the project. Despite this, clear heads were still needed and all safety precautions were taken and the situation was brought under control. The team returned home and rested to gather their thoughts and start to assess once again how best to move forward.

With the state of the ASTREA engine uncertain and the shipping deadline for HELVETIA approaching, a contingency setup was derived. The previous generation engine, DAEDALUS, would be brought out of retirement with the help of team DAEDALUS, and would act as a backup to the ASTREA engine in the case it could not be made ready in time for the SA Cup. In parallel to this, a root cause analysis was performed for the burn through, which was ultimately pinned on combustion instabilities stemming from the pre-combustion chamber. With this information, adjustments were made to the internal geometry of the engine in the pre combustion chamber, as well as adjustments to the insulating liner setup within the chamber. These adjustments were deemed sufficient to prevent the instabilities from reoccurring, and the team moved forward with their last combustion chamber casing. Furthermore, the novel oxygen ignition system was removed and replaced with the legacy system of previous ARIS HRE teams.

Burn through of the ASTREA flight combustion chamber.

With the changes made to the combustion chamber, the ASTREA engine was successfully fired on May 20th. An incredible sense of relief overcame the team and there was finally light at the end of the tunnel. This success was repeated on May 27th, giving the team the confidence in their system to continue with the HELVETIA integration and towards flying the engine at the SA Cup.

The final steps were to conduct full rocket integration tests, which were done successfully, and then finally to prepare for the shipping to the US. All went relatively smooth, and the HELVETIA and ASTREA systems were sent off to the US on June 2nd. The experience at the SA Cup was an incredible once in a lifetime opportunity that also brought with it many challenges. On June 24th, HELVETIA, powered by the ASTREA engine, successfully launched to over 30'000ft above the New Mexico desert, making all of the effort, emotion, time, stress, and excitement worth it! One hell of a ride!



Successful firing of engine in flight configuration.

Carolyn de Oliveira Baumann

Chris Häberli

Dino Fassino

Elias Schwarb

Giorgio Tonetti

Mathieu Sandoz

Max Zappe

Visnusuthan Vairavipillai

1.2 Project HELVETIA

Project HELVETIA was started as the second-generation hybrid rocket developed by ARIS. Being second at something does not seem glamorous at the start and we struggled to find our identity because of that. Fact of the matter is, that doing something for the second time is not only more important but also more difficult.

HELVETIA booth at Spaceport America Cup 2022.

Some people might now disagree, so let us look at science for a good analogue. In science, results are only considered valid and good if they are reproduceable. Only when different people do the same experiment many times and get the same results, then and only then a result is truly accepted. Industry is the same. If a car company only produces one good car and never follows up on it, it is not a very good car company. Having established importance, why is it more difficult to do something for the second time? Everyone who was part of a project knows that there is a very big difference between making something work and making something work optimized, reliable, and as intended. Most of the challenges that we faced during our project came from the fact that we optimized everywhere we could. Reducing safety factors, optimizing length, increasing sensor capability, increasing reliability while at the same time reducing mass. It takes a lot of time and energy to find the limits of oneself and a system, but only when going to those limits you can truly optimize and make something better. Hence, we took on the challenge to morph something that “just” works into something that builds a solid foundation for the future.

Once we had established our project identity and our goals, we felt better moving forward. Especially when thinking about the fact that we were still 49 students that have never been exposed to rocket science before. The task was set, and the clock started ticking down, only 9 months left until launch.

HELVETIA members trying to track the rocket in the sky with their pointers.

Learning rocket science is not really the problem at the start of such projects. It requires research, understanding technical concepts and applied physics. Students have experience in that, as we've been trained in this by our universities. The truly hard thing is, to understand how to translate that into a team effort. How to properly structure a project? How do sub-teams and the communication between them work? How do you unite under a common goal and what are the milestones along the way? After that, the questions become more technical. What designs could solve our problem? What is innovative and what works? Where do we optimize and where do we mitigate risks? How does my design fit into the bigger picture? Where do I get feedback on the things that I've been doing? How do I make sure that it works and how can I test such that I learn something from the test? The process of finding these questions, understanding their ramifications for the later stages of the project and answering them is what we all had to learn in the first few months of the project. This is also the value of doing a project in ARIS, seeing on a hands-on project what the difficulties are and understanding the processes that you have to go through to design and build a rocket.

As these initial uncertainties were tackled, the months and reviews flew by until we already managed to hit the critical design review and the design freeze at the end of December. This meant that it was time to leave rocket science to the side for a few weeks and focus on our studies. In the end we are students and should focus on our academic progress, even though building rockets is a thousand times more fun.

Mission Control set up in the desert of New Mexico at SAC 2022.

After focusing on our exams and taking a few days off, the team was back for the re-kickoff end of February at IPZ in Dübendorf. Full of energy and ready to tackle the challenges ahead. In the meantime, our engine team was already busy with their testing campaign and installing their test stand in the bitter cold mountains of canton Schwyz. Only a week after the kick-off, the Recovery team was already hard at work and attempted, and completed, the first separation tests of the semester. Simultaneously the manufacturing campaign started with the Structures team hitting the autoclave for our in-house composite manufacturing and our Avionics team starting to solder the ordered parts while simulations was starting to include weather statistics into our in-house simulations.

Let us take a step back here. It might seem that everything went perfectly, which is just not true. Student projects are there to create something amazing, but mainly they act as a catalyst to learn and find boundaries and limits. At the same time, everyone also studied next to the project. To invest so much free time, to miss family events, not see friends for months or an entire year…These sacrifices were part of this project. Obviously then the question: Why would you do something like this? Every member in HELVETIA joined for a purpose. Hence, we developed the habit of asking ourselves the question “Why?” During times of hardship and set-backs, we focused on our own personal why’s. Sometimes we also shared our whys, which were always inspirational. We would like to share some of the whys here:

A HELVETIA member overseeing the launch site.

One member of the project never imagined to be doing rocket science a few years back. It never was the goal nor the driving factor in life. That member struggled throughout high school and barely passed classes. No purpose or goal in life at that point. Through a random test that went well, they noticed that potential lies withing them. So, they got to work, joining extra courses, and trying to get into university. Passing the "Passerelle" and in the end making it to ETH. Again, struggling with courses and barely passing the first year, but not for a lack of effort this time, but because the start, coming from Passerelle, is incredibly hard at ETH. Managing, but not with good marks, this person continued with ETH and stumbled across the organization ARIS. Students that build rockets? That seemed amazing, so they applied for a position in one of the upcoming projects, thinking that they will never get accepted based on their grades. But they got into the project! Because grades are not everything. This person showed commitment beyond anything that could be expected, provided effort and benefit to the project without which HELVETIA would never have flown. They went to their limits, found their limits, even pushed their limits beyond what they thought themselves to be capable.

Another member, another why. This member always excelled at school, always good grades, never perfect but good enough. No effort needed, cruising through high school never having to lift a finger. Being okay was enough, aspiration was there but the discipline and will to go beyond was not. Getting into ETH they smelled the opportunity to excel and the effort picked up. But it was ETH and life did not come easy anymore. The need for another work ethic arose, wanting more from life, the long nights followed and discipline developed. But the grades never improved, always good, never perfect but good enough. After some years, motivation began to die down and the question came up if this is really the correct path. At that time, they heard about an organization called ARIS, students building rockets. Finally, something hands-on! No theory anymore, but real-life problem-solving skills in one of the hardest environments thinkable. So they applied, bright eyes hoping to find purpose again, but got declined. So that's the downside of only being good enough throughout life. Accepting reality and going back to their studies, some years passed. They applied again and finally got in. Discovering the joy of working in an interdisciplinary team, once the need for somebody to step up arose and when the project demanded it, they did and contributed in every way that they could to make the project a success.

One of our HELVETIA members always worked on some projects at home. Some cool 3d-prints, some wild ideas, big or small, they always felt the most joy when being able to work on some project. Studying on the side, but never fully focusing on that. After a while, they heard about ARIS, a student organization that builds rockets. That sounded like a cool project to be part of interesting challenges to solve and access resources that they would otherwise not have. Joining HELVETIA, this member put in every single waking hour of their year. Not because of some glorious goal, not because they wanted to touch the stars someday. They did it, simply because they enjoyed the challenge, enjoyed having to make a project work and working on those problems alongside likeminded people. By their own words, they don't care if it's a rocket, a submarine, or a car. As long as the people are cool and the challenge is hard, they will be along for the ride until the very end.

Rocket HELVETIA being erected on her launch rail in the desert.

Let's share one last why: This member never thought about engineering. They focused on finance and did an apprenticeship in that sector. That office job was at a company that happened to have a factory. Walking past that factory every day, they started to develop a certain interest for the things happening in the factory. Being part of building something, designing something that will serve a purpose later suddenly seemed much more interesting than pushing paper for decades to come and then go home after a 9 to 5 workday. Gathering the courage to try a path towards an engineering degree, they first got told by their loved ones, that that is not a clever idea. What if it does not work out? Maybe they do not have what is needed for such complicated degrees and jobs. Gathering the energy to do it nonetheless, extra courses were taken, successfully completed and they managed to enter ETH in an engineering degree. Also struggling at the start, they learned to adapt and managed their courses better and better. After 2 years, they heard about a student organization called ARIS, building rockets. The doubt from the past came crawling up again. Should I apply? They will not take me anyways. Would I even be able to perform? Gathering the courage once more, they applied and got accepted. Joining into the project and delivering excellent work every day since. Taking on their responsibilities and always handling them with excellence. Additionally, taking on other responsibilities, not because they wanted to but because they needed to in order for the project to be successful. Managing to make a rocket fly, that otherwise would not have.

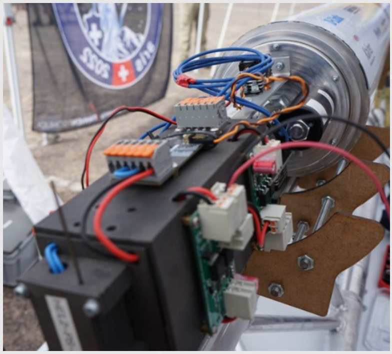
Entertaining judges at SAC… or vice versa?

These are 4 whys of 49 different why's. When we had failures and the times were dark, we remembered our own why and some of us shared their why with others. Strengthening us as a team, encouraging each other to move on from failures and push forward. After sharing some of our whys, let us have a look at the failures that required us to remember them.

The engine section being readied for integration into the rocket.

During early spring of 2022, the engine team had multiple weeks of delays, due to a multitude of reasons, cutting their firing campaign short by months. The Recovery team had a switch in leadership and had to find their way forward again, leading to some down weeks and mounting challenges. Our entire Avionics team dropped down to only 1 single person for a short while before some recruiting efforts put that number back to 4. These new members still had to adapt to a system they did not design, leaving the bulk of the work at the start on one person. The Structures team had multiple failures in manufacturing, setting their timeline back almost a month as well. This is a huge oversimplification of all the events that took place during that semester. Every week, sometimes even daily, problems popped up that could mean the end of the entire project if not fixed accordingly. But the team hung on, we solved the problems and moved on to the next problem.

All of this culminated in an engine failure early May that lead to the leadership discussing commercially off the shelf 10’000ft solid motor backup options. Only four weeks before the shipping deadline to the USA. This would have set the project back to a technological level the association last saw over three years ago. Developing three different systems in parallel, the engine team succeeded and the team in the end managed to have two different working configurations with two of our own hybrid engines. Doing one final test in the form of a wet dress rehearsal that had dozens of problems showing up. It required an immense mental and physical effort by the team over a duration of 36 hours that concluded our semester. We had a system that worked and that was on its way to the competition. As they say, the rest is history. Our journey at the competition has been well documented in past newsletters, but here is a short version of it:



The tank section being readied on the left, Recovery electronics on the right.

Arriving a week early, the recon team had to fix many logistical and technical issues until the rest arrived. The competition was amazing and a wonderful conclusion to an amazing project. Meeting different teams from all around the world, sharing knowledge and discussing rocket science was an incredible experience. The launch attempts were once again filled with problems. On the first day, a hundred-year weather event lead to the desert being flooded and streets washing away leading to the launch pads being closed. We therefore had to do another Dry Launch in the parking lot of our hotel to find and fix some last-minute problems. Waking up at 3AM the next day and starting our launch operations at 4AM in the desert, we reached the launch pad with our rocket at 5PM. We had to scrub the launch shortly before 6PM due to another storm moving in. Devastated and exhausted, we moved back to the hotel after over 16 hours of hard labor in the desert.

Remembering our whys at this point gave us the strength to wake up again the next day, repeat our launch attempt and get the rocket onto the launchpad by 3PM. Battling problems like malfunctioning generators, to the heat leading to faulty electronics and randomly opening venting valves, the team managed to get the rocket filled and launch ready. At 17:24 local time in the desert of New Mexico, team HELVETIA managed to launch their rocket to an height of 10.4km with hitting Mach 1.2 and a perfect dual recovery. In the span of only 9 months, we went from 49 random students, never having done rocket science, to launching a hybrid rocket in the USA. This would never have been possible without the amazing team and the whys every single person brought with them. Banding together and bonding as a team, helping each other out, is what made it possible to prevail in the end. Thank you to every member, thank you to every supporter over the past year and thank you to anyone who helped us at some point throughout the last year. There were so many close calls over the duration of this project, that it would not have worked if only one person would have given up at any point. Thank you for staying until the end.

Rocket HELVETIA lifting off the launch rail in all her beauty.

Rick Röthlisberger
Dominic Frehner
Marc Zaugg
Ianco Cregut
Noa Lévy
Constanca Tropa
Alexander Hüssy
Andrei Parvulescu
Ingebrigt Hovind
John Dornbierer
Kai De Windt
Simon Arrenbrecht
Timo Büeler
Carolyn de Oliveira
Baumann
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Robin Jeger
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Fabian Kolodziej
Fabienne Maissen
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Philip Ploner
Ryan Meierhofer
Xuanting Meng
Francesco Scotto
Jan Seyfried
Ryan Wüest
Samuel Russo
Yannik Werner
Yash Sinha
Zhenwei Xu

Adrià Munoz
Andrea Stifel
Andreas Hirsch
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Jan Mathys
Lasse
Matthias Bürgler
Robert Andersson
Sam Donaldson
Yannis Kafantaris

Aaron Ehrat
Alea Stricker
Anna Sulzer
Lars Horvath
Sean Bone
Simon Höhner
Valerio Schelbert

1.3 Project LEA

Project LEA was initiated in the beginning of 2021 by students who had previously been part of the IRIDE Focus project in 2019/20. The main motivation was that ARIS had already gathered a lot of experience in developing hybrid rocket engines, however it had become clear that in order to launch to higher altitudes and to become more efficient, the organisation had to start developing liquid rocket engines, which are the industry standard. This new project would not only be an opportunity to build a knowledge base of liquid rocket engine technology but was also a chance to optimise testing strategies of rocket engines at ARIS. Project LEA was founded with the following three goals:

1. Build a small-scale modular liquid rocket engine which allows for different testing configurations and uses cryogenic liquid oxygen (LOX) and ethanol as propellants.
2. Build a mobile test bench suitable for LREs and HREs to facilitate rocket engine testing and make iterative testing possible
3. Develop and build a flexible data acquisition and control system

The test trailer in transport to the airfield. Ready for firing.

The Team

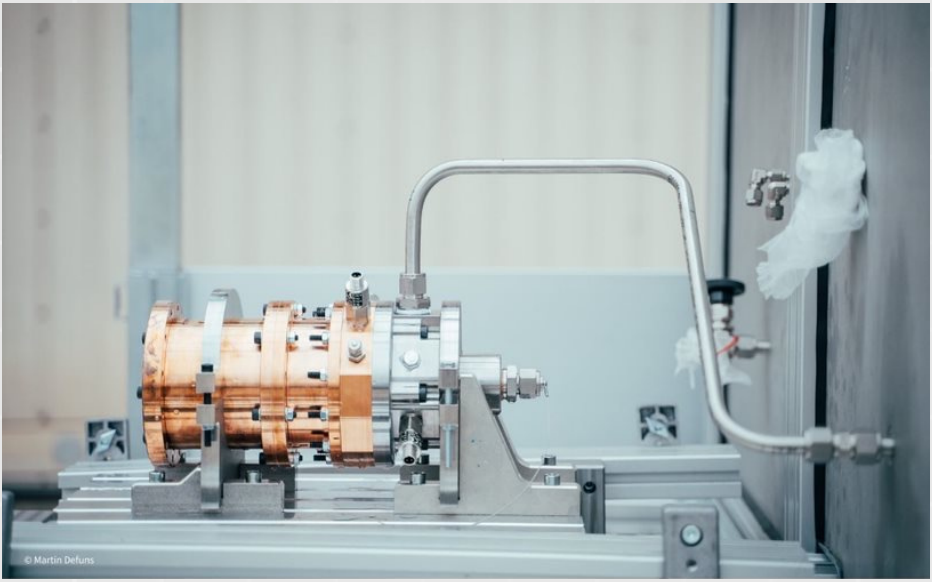
Team LEA consists of about 30 ETH students, most of whom are mechanical engineers. Every member works as a freelancer for the project and does not receive credits. The members were recruited in the summer break of 2021 by the project founders. Most members were in their second or third year of their bachelor's degree and had not previously been part of ARIS. The team structure consisted of four sub-teams; Engine, PSS (Propellant Supply System), DACS (Data acquisition and control systems), and management which was made up of the PM, Safety Officer, and the three sub-team leaders. The team organised weekly meetings and working days in these groups. In addition, interface meetings were held, where inter-sub-team topics were discussed. Furthermore, during bi-weekly team meetings the whole team would be informed about project progress, next challenges, budget status, timeline and other general discussion points.

Team LEA in front of their engine test trailer.

The Project: LEA 1.0

The team started fully working on the project after the kick-off in September 2021. In the first half year the team mainly worked on designing and planning the system. The engine team designed and engineered a modular rocket engine. The propellant supply system team designed and built the piping system which would supply the engine with LOX and ethanol. The propellant supply system also includes a pressurization system and a purging system. Together these two sub teams also worked on the test bench design and, came up with various safety constructs for the test stand. The DACS team worked on developing an adaptable data acquisitions system the goal of which would be to make data analysis faster and easier. They also implemented several safety features like defining maximum pressure in different parts of the system which would trigger an abort if exceeded. Additionally, the DACS team picked out sensors and defined what data was relevant to be gathered for research or for safety features. The team went through the usual ARIS reviews, SDR, PDR and finally CDR. Over the winter break, manufacturing started and with the spring semester the team began to do hands-on work on the trailer. Once the base structure on the trailer was built, the PSS sub team dedicated many hours to bending, cleaning, and assembling pipes. The propellant supply lines then all had to be leakage and pressure tested. Meanwhile, procedures for tests and firings were drafted and reviewed countless times until approved by the ARIS safety advisory board (SAB) and all members were content with the outcome. During the first leakage and pressure tests, the team was able to gain some experience for the firings, perfecting the procedures and becoming more and more familiar with the whole system. The DACS team assembled and wired all sensors to the DACS electronics box on the trailer. Not only did the team work on building up the system but also the team spirit grew in this phase. Working together with like-minded, passionate people, growing together, and going through failures and successes together, is truly a valuable experience. And perhaps the most unique and beneficial aspect of being part of an ARIS team. Not only do we learn to be better engineers, and gain knowledge on combustion processes, coding, planning and executing rocket tests, and everything else concerning rocket science, but we also learn something even more important. We learn to be better teammates, friends and how powerful sharing a passion and vision can be.

Due to the circumstances of the pandemic and tensions in the East, there were many unforeseen delays, especially when manufacturing the engine. Additionally, team LEA had only found a sponsor for cryogenic valves in the winter of 2022, and producing these valves would take too long for the project. This put the team in a tricky position and forced the team to re-evaluate project goals and timeline. Initially, the goal had been to test the rocket engines with LOX as an oxidizer, however, due to the late order and delivery delays, the necessary valves needed to operate at such extreme temperatures would not be available in time. Luckily, when taking a modular approach and with the design of the test stand being very flexible, the team had developed a test stand that could easily be adapted to be suitable for nitrous oxide as an oxidizer. Some small design changes were made in some of the injectors.



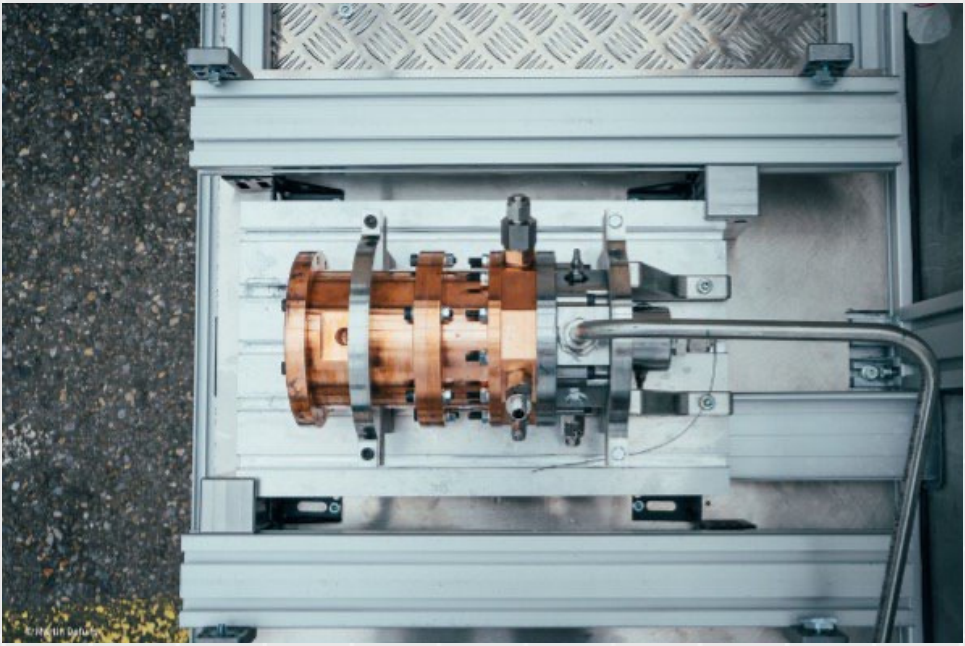
The copper engine mounted on the trailer.

Finally, the engine parts arrived, and the team pressure- and leakage-tested all parts. Additionally, sensors and safety abort sequences could be tested. After countless hours spent testing and getting to know the system on the airfield, the team was ready for the first cold flows. During these tests, the team continuously improved the system and test setup. Adding features like LED lights which would facilitate testing late at night or improving procedures to make testing more efficient.

The team pushed hard, with the goal of firing the engine for the first time before the summer break, however, due to the delays the team experienced it was not quite possible. The team went to study for the summer exams and take a well-deserved break, before returning to the project in the new semester with new motivation.

The Engine

There is one conventionally manufactured combustion chamber and nozzle, which is made from the copper alloy Hovadur. This material acts as a heat sink to cool down the engine, however it limits the maximum firing time to five seconds. The second rocket engine designed by the team uses regenerative cooling in order to make longer firing times possible. For this, the additive manufacturing process was used with the material Inconel 718 which is suitable to withstand the high temperatures and stresses of a rocket firing. An optimal cooling allows the rocket engine to fire for up to 20 seconds. There are two injector designs, impingement hole injector and a coaxial swirl injector which can be mounted onto both engines. The torch igniter can also be used for both engines. The igniter is fuelled by propane and gaseous oxygen.



Top view of the bi-liquid engine.

The testing infrastructure

The aim of the team was to test the rocket engine on the airfield in Dübendorf, not in Ochsenboden, as done previously by the hybrid rocket engine teams. The advantage of testing on the airfield are the proximity and the absence of transportation costs. This made it easier for the team to move between hangar and testing location and generally greatly reduced testing times. The engine, PSS, and DACS are all mounted on a trailer which can be hitched to a car or pushed to the runway by hand. The trailer is then connected to a mission control room, located in a small building called the Hunterstübli next to the runway.

The LEDs of the trailer do not only look fancy, they also indicate the system status.

The Project: LEA 2.0

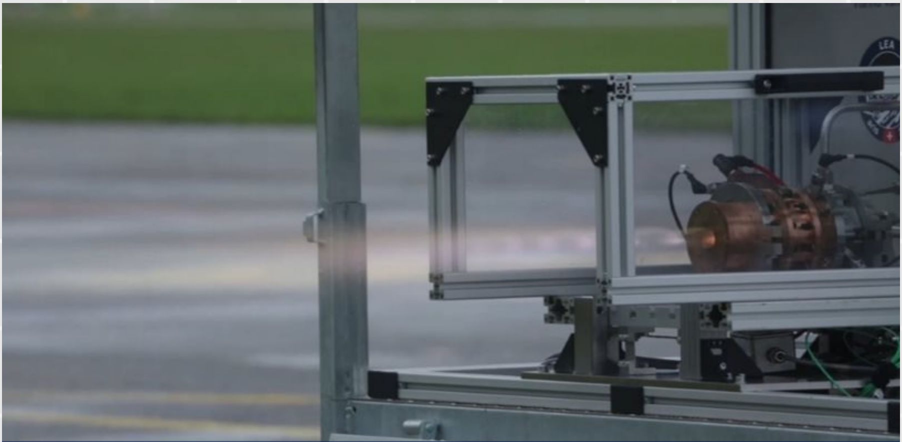
With the start of the autumn semester 2022 the team was ready to start with the N2O firing campaign. Some last improvements had been made over the summer and the team and system were more than ready to finally conduct the first firing. Starting with the conventional engine with the impingement holes injector configuration at a firing time of 2.5 seconds, the team was able to successfully fire for the first time. After having evaluated the gathered data and being satisfied with the results, the team conducted another firing in the same set up to verify the data and test the systems reliability. Next, the firing time was increased to 5 seconds and the team also managed to conduct several firings in a row.

This fast and iterative testing is novel to ARIS and will help the association develop engines faster than ever before. The team also tested the additive manufactured rocket engine, which uses regenerative cooling. The feeling of successfully firing an engine after having worked on it for over a year was unforgettable for the team.

Side view of the trailer with the Hunterstübli in the background.

The Project: LEA 3.0

Together with the focus project, PROMETHEUS, which will take over the system in 2023, team LEA is preparing the system for liquid oxygen firings. This phase began in the first week of November and will continue until the end of the year. The goal is to implement the cryogenic compatible valves, pressure and leakage test the system, and clean it for oxygen service. Furthermore, the coaxial swirl injector will be tested in this system configuration, and increased firing times will be made possible with the regeneratively cooled nozzle. The team is looking forward to gaining experience with cryogenics and building a knowledge base for ARIS, which will be crucial for the long-term goals that ARIS has set. Passing on knowledge and experience is very important to the team and the focus of the team is on ensuring a comprehensive knowledge transfer to the next generation of liquid rocket engineers. We are proud to have achieved so much, and bringing the association closer to its goals



Successful test firing of the LEA engine.

Alexander Jürgens

Alexander Perozzi

Amedeo Caserta

Anna Möri

Azra Smajic

Bastien Smette

Bruno Berger

Felix Winghart

Gian Kaufmann

Guido Moor

Jan Weber

Jonathan Dotzler

Julius Wymann

Lars Müller

Lea Knoebel

Loi Tony Ngo

Manuele Rossetti

Mathieu Sandoz

Matthias Weigl

Max Wehr

Mirela Minkova

Nicolas Triebold

Nicolas Maier

Nicolas Dirnegger

Nicole Wenzinger

Pascal Müller

Philip Wolf

Piotr Tuzlak

Raffaele Di Giacomo

Shady Elshater

Sofia Talleri

Stefan Schmid

Till Matzner

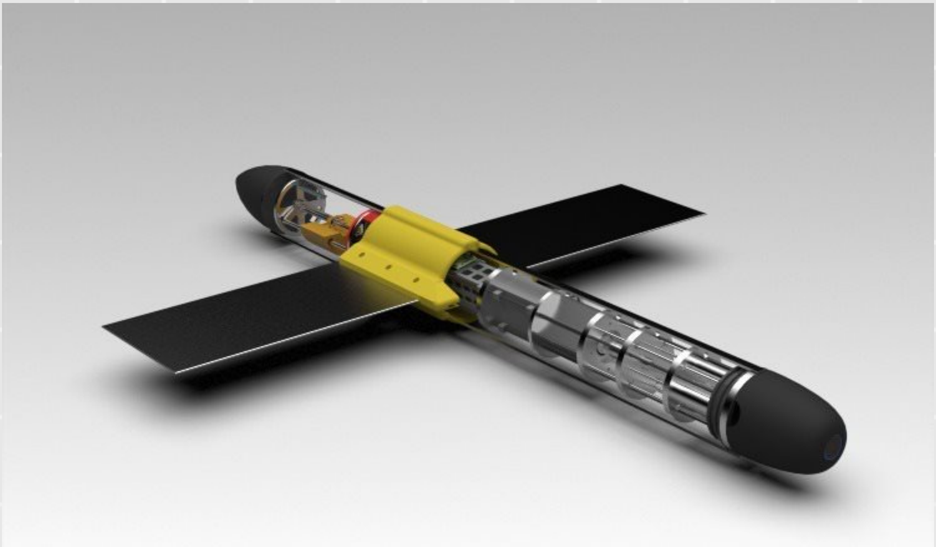
Timo Büeler

Vishnu Varadan

1.4 Project NAUTILUS

When project Nautilus was officially kicked off in September of 2021, many unknowns were still to be defined. However, the vision of the project was already very clear to each of the newly recruited members. Build an Unmanned Underwater Vehicle (UUV) capable of exploring the subterranean oceans of icy moons in our solar system in search for extraterrestrial life. The vision centers around the idea that if we were to find alien life close to earth, then it would very likely be on one of those moons e.g., Enceladus, Europa or else. It is a goal of many international agencies to fly such a mission in 30-40 years and project Nautilus could realistically provide input and experience for planning these missions, if the project was successful. While the challenge of working on such a complex task already seems to be big enough for a student engineering team, Nautilus additionally decided to implement new principles in the area of robotics into the UUV design. In collaboration with researchers at Swiss Federal Laboratories for Material Science and Technology (EMPA) the field of Soft robotics was chosen. Soft robotics have been shown to deliver superior capabilities in on land gripping but more importantly in underwater propulsion.

Many of the standard propulsion methods such as propellers have always been inferior to nature's own methods of underwater navigation. Animals like fish outswim a classic inspection robot not only in range but they also achieve much higher maneuverability underwater. By using soft silicone parts actuated by various methods, current robotic research is trying to mimic this behavior and create biomimetic robots. One of many good examples is the soft robotic fish SOFI, very recently also featured in a TED Global talk. The idea of NAUTILUS was to utilize these soft robotic approaches and incorporate them into a vehicle designed for space. This way we could potentially show this new robotics principle in a space environment and thus support research.



CAD render of the NAUTILUS system.

Minding the novelty of this field, the team didn't start out with knowing what the soft part of NAUTILUS would look like. It first had to be invented. However, a few other constraints were known. The UUV should be designed with the idea in mind to deploy this in an icy moon's subterranean ocean. In terms of navigation this means that one would expect high turbidity and low light settings. Further, due to the thick ice layer we're operating under resurfacing and correcting the current position estimation using GPS would also not be an option. In terms of structures the mission requires high robustness against any collision due to the unknown situation under the ice. Too many further constraints to mention here in detail also arise. Based on a weighted analysis of all of them the NAUTILUS team came up with a design for the whole UUV and for the soft wings. The UUV design itself is centered around the concept of an underwater glider. By varying its buoyancy, the glider can move up and downwards inside a water column. Using its wings to each side, the glider can then translate this up and downwards motion into a forward propulsion. This method of moving forward underwater is highly efficient, which is very important to a mission into icy moons like Enceladus. Conserving as much of the limited power reserve as possible while covering the longest distance and thus gaining the most knowledge on this unknown world is key to any extraterrestrial exploration.

For the soft robotic part of the UUV similar considerations were made. Increasing maneuverability and efficiency while not compromising the general propulsion method seems hard since commercial gliders already exist and are precision engineered tools used for example in defense applications. The NAUTILUS concept challenging these is using soft robotic wings. The idea of those wings is to bend individually and thus provide any desired amount of lift and drag force in every situation of the forward propulsion. Should the soft wings prove to work the planned, they could then substitute the attitude control unit (ACU) of the glider, minimizing the number of moving parts inside the UUV and maximizing desired control features.

Finding a concept to actuate soft robotic wings and the subsequent means to manufacture them took the team until the end of October 2021. Many literature reviews and discussions with researchers at EMPA were necessary to arrive at the final concept. This was then presented at the System Definition Review (SDR) presentation on 22.10.2021. Various Professors and experts from different locations attended including the UK, Germany and Switzerland. The team was then able to use the valuable feedback gathered from this SDR and include it into the UUV design. While more classical engineering parts of the UUV like connectors and such were still in continuing design process, the team started to prototype the soft parts already in October. This is due to the many difficulties silicone poses when shaping it according to our design needs. For this a completely new manufacturing procedure was introduced at the NAUTILUS facilities at EMPA, including the casting of a wax core which would then serve as a mold casting silicone around it and then melting the wax core out again.

While still in development the project was slowed down by the study period and subsequent exam session during the winter. Realizing the need for more workforce and the possible research aspect of the project two new bachelor theses were introduced to NAUTILUS. One focusing on developing the ACU was supervised by Prof. D. Farinotti and the other focusing on the soft robotic wing design was supervised by Prof. R. Katzschmann. Both theses were co-supervised by Prof. M. Kovac, head of the Material and Technology Centre of Robotics at EMPA and a professor at Imperial College London (ICL).

Initial tests of the system in a pool at EMPA.

At the Re-kickoff event in February the team got exciting news regarding the possible implementations of the NAUTILUS project. Prof. Farinotti was offering NAUTILUS the option to deploy our system in glacial lakes in Switzerland and get contacts to the Swiss Polar Institute (SPI) for possible further sponsoring and collaboration on implementing the system. Subsequently, the mood of the team increased again, and everyone worked very hard until the summer to finish the project. The ongoing development was shown in two reviews, one being the Preliminary Design Review (PDR) and the Critical Design Review (CDR) in April. After this the manufacturing period began.

Unfortunately, not all parts of the UUV could be finished until the end of the first year of development. Due to its niche setting in robotics many challenges arise for NAUTILUS, which engineers usually don't encounter. However, the ACU and the soft robotic wings were finished until the summer. The work on the wings was manifested into a scientific paper which at the time of writing is awaiting submission. This will hopefully prove to be valuable scientific output and increase ARIS' visibility in research.

Currently the team is working on finishing the electronics, the buoyancy control unit (BCU) and the software of the UUV. The team is hoping to move to testing the UUV in late November and hold a performance review mid-December. After the many challenges we faced, all team members are really looking forward to seeing the UUV in water. It has been quite a journey until today and it will probably continue to be a difficult one in the future. However, the project has evolved a lot and has already been able to unlock new territories for ARIS in research.

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Dario Bozinovski
Dion Stöcklin
Fabian Wiesemüller
Florian Kaufmann
Ghazi Cherif
Jorit Geurts
Lam Nguyen Thiet
Liam Achenbach
Luca Dofing
Luca Sacchi
Lucas Catellani
Lukas Lieb
Lukas Petersson
Marco Trentini
Marvin Tüscher
Matthias Forestier
Maximum Wilder-Smith
Niccolo Faccenda
Nico von Moos
Noah Koller
Oscar Kläsi
Per Frivik
Ramon Heeb
Raphael Vidoni
Ryan Wüest
Simon Bauer
Simone Morandi
Théo Schäfer
Tino Sonnenschein
Yannic Hofmann

1.5 Project PERIPHAS

Many times – especially in student rocketry – the importance of a successful recovery of a rocket can sometimes be overlooked. With project PERIPHAS the aim was not only to not only provide a completely reliable recovery system, but to take it a huge step further: To develop an autonomous guided recovery system, which is able to steer itself during descent to a designated area.

Team picture taken at the European Rocketry Challenge in Portugal in October 2022.

Why would this be of importance? With ARIS' aim to fly to the Karman Line in the next 5 years, the recovery of rocket parts from higher altitudes will get more and more challenging. A guided recovery technology could enable a rocket to launch over the ocean for safety but recover itself back to land once it has successfully completed its mission. Furthermore, the challenges of realising such a system can display technical excellence of ARIS as an association which aims to spearhead new space technology in student rocketry. The task was clear, but how was this tackled?

Design Phase

The project started with ten focus project students from both ETH & ZHAW. The team quickly realised that just building a recovery system wasn't enough, we wanted to actually launch the system on a rocket and make it flight-proven at the European Rocketry Challenge 2022 in Portugal. An international European competition organised by the Portuguese Space Agency. So pretty soon after the start of the project members from the ARIS project EULER were recruited to build the lower part of the rocket. Basically, making the PERIPHAS rocket a hybrid between new and "old" ARIS technology.

We got to work on the design phase of the project until the end of 2021. The amount of design work, blood, sweat and tears that went into these 3-4 months can't be put down in a few simple lines of text. The team went through ARIS' rigorous review process and came out with a final design before Christmas. Parts were sent to acquired sponsors for manufacturing and things quieted down over the ETH exam phase.

The design choices made were based on performance, practicality, and the existing designs of predecessor project PHOENIX. It was decided the system was going to integrate a ram-air parachute, which is the same one you would see a skydiver use. It can be steered during descent by two motors inside the system. The motors are actuated by a completely self-developed software running on electronics designed by the team.

Shortly after the exam phase is where things really kicked off. The structures team got to work on manufacturing all carbon parts of the rocket themselves while aluminium parts arrived from sponsors. The other subteams like Software & Electronics were busy setting up and testing the hardware and in a sense the framework on which our autonomous guidance algorithm would later run. The Guidance, Navigation & Control (GNC) team itself was busy setting up the simulation environment where we could later run useful simulations of the descent and lay out an autonomous controller

Cargo Flight

After a lot of subsystem tests it was finally time to put the entire system through its paces for the first time: A cargo flight.

Cargo flight of the system.

The goal was to fly the entire system under a helicopter of the Swiss Air Force and test the separation mechanism for the nose cone in-flight. The system would stay attached to the helicopter the entire time. Also, this test would serve to validate the telemetry connection and finite state machine in our software, making sure that all those state changes worked well triggered through our ground station.

The system took flight for the first time and the helicopter turned a few laps around the airfield in Dübendorf. The nose cone separated perfectly and the test was a complete success. We were now ready for the next step of our testing campaign: The droptests.

Drop test of the system conducted in the Swiss Alps in Kanton Glarus.

Droptest Campaign

Over the summer of 2022 the system was subjected to seven droptests in the Swiss mountains of Glarus. A test where the system can go through the entire recovery phase of a rocket launch without performing a launch. The system was hooked up to a helicopter of the Swiss Air Force and subsequently dropped from more than 1000 m above ground.

The first few droptests were used to gather data on the behaviour of the system. Which basically means that the inputs on the parachute were hardcoded in the software (Pull 50 cm of line on the left, then on the right, etc.). This way we would gather data on the behaviour of the system according to our inputs. After five droptests – some of which were unsuccessful due to various reasons – we had enough data to correctly simulate our system in our simulation environment. This allowed us to implement a more complex guidance algorithm in our simulation environment and with it a simple controller to steer the system autonomously. This guidance was tested during the sixth droptest and it worked beautifully! The system was now able to follow a heading reference with ease.

During six droptests the team was able to – with a few setbacks – develop an autonomously flying system. This achievement can't be understated as it is a first in student rocketry, and the amount of software development that went into it was considerable. We were finally able to steer a rocket during descent!

Maiden Launch

With the milestone of guided descent behind us the team focused on achieving the next goal that we set out at the start of the project. We wanted to actually fly the system in a rocket and test it during a rocket launch before we went to the European Rocketry Challenge. This test would serve as a final rehearsal for the launch in Portugal.

The necessary team and structures around building such a rocket – and not just a recovery system – were assembled months in advance. After the necessary preparations a rocket launch to 1100 m was approved in Switzerland where we had previously conducted our droptests.

There are considerable work packages that come with such a full system flight-test. The organisation and coordination alone of such an event coupled with the preparation of the system took in weeks before the maiden launch. But the goal of testing the system in-flight and the data and knowledge acquired through such a test were incredibly valuable.

Rocket PERIPHAS mounted on the launch rail, ready for its Maiden Launch.

And so on August 13th PERIPHAS took center stage in the Swiss Alps and ignited its engine. But around 1 second after leaving the launch rail the rocket tilted hard to the left and flew off at around a 60-degree angle from the ground. The system crashed into the mountainside, and we were not able to demonstrate our guided recovery system to the many attendants at our launch.

The hard work of almost 12 months had been destroyed in a matter of seconds, this was a low point for the team. Something had gone wrong during ascent, and we needed figure it out, since just under two months later we needed to launch again. This time at the European Rocketry Challenge in Portugal.

Rocket being readied for its launch at the European Rocketry Challenge 2022.

European Rocketry Challenge 2022 (EuRoC)

The issue at maiden launch was traced back to a critically low velocity at the moment the rocket left the launch rail. This issue was mitigated as we had a more powerful engine for EuRoC. The goal was to fly to 3000 m apogee, using the already established airbrake system from the 2020 EULER rocket. This system extends aluminium scoops outwards from the rocket's hull to slow it down during ascent and target a precise apogee.

The team arrived with a rebuilt rocket and high spirits and settled into EuRoC. Tackling different challenges like the Flight Readiness Review and a Jury Pitch during the first two days. During these reviews the safety and readiness of our system as well as the overall philosophy behind our project was scrutinised. We passed with flying colours!

We intended to launch on the third day of EuRoC, which was the first possible launch day. Unfortunately, due to some issues with our electronics we had to move our launch back by one day. The issues that encountered were fixed and we woke up on Friday the 14th of October ready to tackle the final launch of PERIPHAS.

Launch day began at 5:30 AM so that we had enough time to get to the launch site located at a military shooting range just under an hour away. We were the first ones there. While it was still dark, we were unloading our van into our assembly tent.

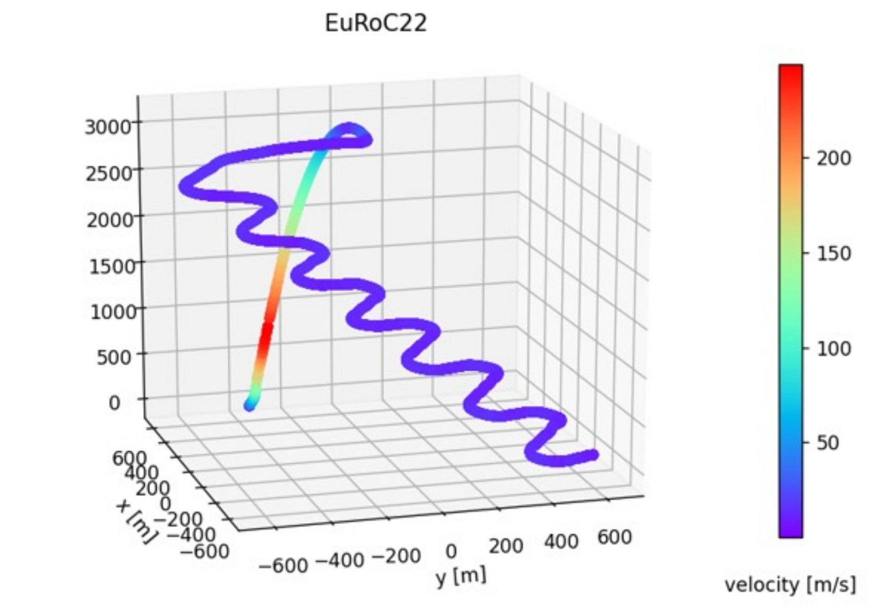
The assembly of the rocket took the entire morning. It went smoothly and no major problems occurred. By this time of the project the team worked like a well-oiled machine. After so many droptests and a maiden launch every move was done with a sense of security. With 30 minutes left until our launch window opened it was time to move the rocket to the launch rail and mount it, so that it would be ready for launch.

The rocket was erected, the igniter was inserted and final GOs were given for launch. Nerves built up as it was counted down over the PA-system “3, 2, 1…IGNITION”. For a couple of seconds, nothing happened. Those were the longest seconds in the entire project. Then suddenly a plume of smoke. And she there she went! With just below the speed of sound PERIPHAS ascended to 2970 m in a beautifully straight line, deployed its parachute, and went on to demonstrate guided descent in front of many excited onlookers from all over Europe. The descent was eagerly follower by everyone as PERIPHAS slowly made one turn after the other. The flight was a complete success.

Lift-off for rocket PERIPHAS at the EuRoC 2022.

The rocket was recovered laying in a bush, completely intact. The joy within the team cannot be described. After a failed maiden launch we pulled ourselves together and took ARIS one step closer to its goals in the future. It was a truly amazing moment for PERIPHAS and ARIS, also as we were able to demonstrate a new degree of technical excellence.

The team wants to thank ARIS and all its supporters for making this project possible. We hope that the technical legacy of PERIPHAS will live on!



Real position data from the launch of PERIPHAS at EuRoC.

Anna Sulzer

Daniel Schmid

Dominik Dedic

Emre Elbir

Fabian Weber

Frederic Strickler

Janko Uehlinger

Jonas Binz

Julian Santen

Junyuan Cui

Luca Jost

Max Leeb

Moritz Kuntze

Nemanja Stojoski

Nicolas de Maddalena

Paviththiren Sivasothilingam

1.6 Project SAGE

The SAGE CubeSat project started one year ago with the goal of bringing the first satellite from the German speaking part of Switzerland to Space. The fully student-led project developed three mission objectives. First is artificial gravity generation that creates micro- and milligravity conditions as found on small moons and asteroids. The goal is to operate the satellite as a centrifuge and therefore provide a long-lived test bed for research that cannot be found today on earth. Second is scientific research. With the mission, SAGE wants to contribute to cutting edge research in the field of aging in space. The biological payload investigates the senescence of cells in the milligravity condition. The third mission objective is to contribute to space related engineering and science in Switzerland. SAGE provides the opportunity to gain hands-on experience with space missions and access to advanced aerospace engineering and research for students from all over Switzerland.

Team SAGE aiming for orbit.

Who is SAGE

SAGE consists of 30+ students from more than ten different disciplines including mechanical and electrical engineering, material science, physics, biology and chemistry. In SAGE we promote excellence and diversity. With 80% of the students being in their masters degree, SAGE members bring a high level of knowledge and experience to the mission. SAGE strives to be a positive environment for women in STEM, which is seen with 40 percent of the members being female.

Delegation of SAGE members at the ESA Fly Your Satellite Challenge.

SAGE 21-22

SAGE started the fall semester 2022 with a team that was completely new to satellite development. Within a time frame of two months the mission definition review (MDR) was held. There the goals and trade off analysis of the mission were presented. After the MDR the team continued on the drafting the requirements. At the System Requirements Review (SRR) in April, the team passed their mission-, system- and sub-system-level requirements, which meant that now they were equipped with a whole of 303 requirements. With a clear vision ahead, the team started working on their preliminary design. To verify the mission objectives, the control system, and the biological payload, a parabolic flight campaign was planned. The preparations began right after the SRR and half a year and a Test Readiness Review (TRR) later, the test week was there. In a total of 3 flights the control system, the antenna deployment mechanism, the survival rate of the human cancer cell line, as well as the Paylaod's pumping system could be tested and verified.

Payload Engineer working with the biological cells.

Parabolic Flight Test Team in front of a hangar in Dübendorf.

The parabolic flight was also a highlight for the three team members who were chosen to perform the experiments in-flight as well as the ground support team. With the data from the parabolic flight the team continued to the internal Preliminary Design Review (PDR). This same week as the parabolic flight, SAGE also submitted an application to the ESA Fly your Satellite! Design Booster Challenge, a programme supporting student satellites with the design and verification of their CubeSat and was admitted. This meant that 7 members of the team were able to participate in a week long workshop at the ESTEC facilities in Nordwjik, NL. The workshop provided the team with valuable insights and lectures from ESA experts about CubeSat Design and gave us the chance to exchange with eleven other CubeSat teams from all over Europe.

Parabolic Flight Test Team ready for take-off.


Team SAGE assembling their system.

SAGE 22-24

In November 2022, the team was extensively preparing for the external PDR that was held on four consecutive days. After a successful PDR at this stage, we will move on to Phase C, the critical design phase. Phase C will include major technical advancements, a lot of testing in form of a flatsat and a structural thermal model (STM) of components and systems as well as locking down the design of our CubeSat. The critical design review (CDR) will be held end of Q2 of 2023, just one year before the planned launch date. After passing the CDR the team will move on to the Phase D, the assembly, integration and verification phase. This phase also includes the qualification and acceptance testing of the single parts, as well as the whole system. Once the system passes all required acceptance testing, it will be ready for launch.

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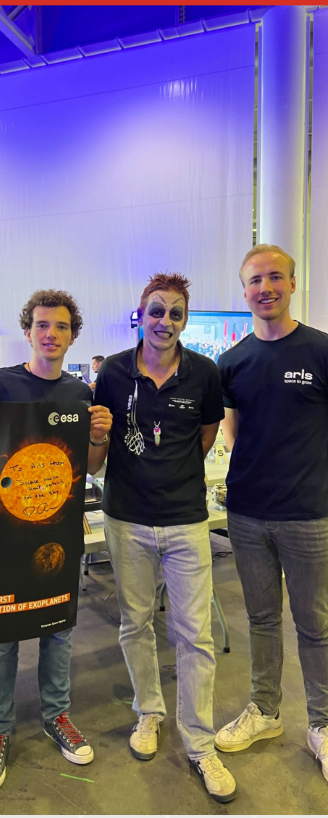
Anita Berg
Araceli Rodriguez
Benno Bösch
Berkay Isik
Blanca Crazzolara
Carolyn Baumann
Clément Lefebvre
Cyriac Tomas
Daniel Repérant
Dario Tscholl
Dennis Lücher
Dennis Lüscher

Eric Goldhahn
Fabienne Maissen
Fiona Konnerth
Gaia Lauper
Horvath Lars
Hugo Umbers
Ida Dittrich
Jonas Meier
Jonas Schlör
Konstantina Psaraki
Leonardo Barcotto
Lukas Hofer
Manuel Wyss

Martin Portmann
Marvin Griener
Moosmann Julian
Pablo Álvarez Domíngue
Pietro Bonazzi
Rabea Rogge
Sami Bouziri
Simon Tobler
Soraya Daabak
Tim Wünsch
Tsubasa Fabbri
Vishnu Varadan
Woodtli Chantal
Yannik Thuring

aris
space to grow



2. ARIS Financial Close Report 2021/22

2.1 Financial Report Executive Summary

We are proud to inform you that ARIS is yet again in a good fiscal shape and has achieved all its financial goals.

The emergency funds have been further increased by 1/3 from CHF 15’000 to CHF 20’000.

ARIS **started the 2021/22 cycle with a net margin of CHF 20’346.54**. The **total revenue of the 2021/22 cycle was CHF 153’189.92,** a decrease by 16% compared to the prior cycle. The **total cash expenses for 2021/22 amount to CHF 143'043.49**.

This leads to a net closing of the financial cycle of 2021/2022 with a profit of CHF 10’146.43. Adding up the financial results of the previous years, leaves the association budget with a **net margin of CHF 30’492.97 to start the 2022/23 cycle**. One of ARIS’ primary goals is to ensure its non-profit nature. Hence, this amount will be used to kick-off the 2022/23 projects.

The cash expenses of the individual teams of the 2021/22 cycle can be observed in the table below:

LEA Expenses	CHF 18'365.56
SAGE Expenses	CHF 4'350.00
NAUTILUS Expenses	CHF 2'975.00
ASTREA Expenses	CHF 11'100.00
HELVETIA Expenses	CHF 46'075.73
PERIPHAS Expenses	CHF 21'035.50
PICCARD Expenses	CHF 4'729.84
DAEDALUS Expenses	CHF 1'314.20
PHOENIX Expenses	CHF 4'988.32

The upcoming financial year starts with CHF 61'501.55 already allocated for the upcoming expenses and CHF 30’492.97 free to spend for next year’s teams.

The following activities come up on the horizon:

- Keep increasing the emergency provisions fund. The goal for the next financial cycle is to reach CHF 25,000 in emergency provisions. The long-term goal is to set aside about CHF 30‘000-50‘000 which relates to approximately 10 % of the annual budget which will be considered as reserves but exceptional payments.
- Plan budgets more accurately, ideally exploiting the actual expenses from past years as a benchmark. Create a standard template that will be used every year.
- Increase the cash sponsoring amounts by a significant amount in order to account for the increasing cash needs for more complex projects like SAGE and ODYSSEY.

2.2 Overview

2.2.1 The ARIS Finance Unit

The finance unit of ARIS aims to make cash-flows smooth, simple and clear for ARIS and external reviewers. Members of both the finance unit and the association board oversee the finances to ensure that the basic principles are fulfilled.

01	Tracking financial resources	Transparency	01
02	Managing cash flow and liquidity	Accuracy	02
03	Determining financial needs	Completeness	03
04	Executing transactions	Consistency	04
05	Reporting	Stability	05

2.2.2 Process and Oversight

The ARIS board, PMO and internal auditors provide financial oversight through 4 cycles:

- Weekly review of team needs as part of the association management meeting
- Bi-weekly financial report for the approval by the association board
- Quarterly budget, approval by the association board
- Bi-yearly book auditing, approval by internal auditors selected by the general assembly

#Weekly	Team-needs cash	Provision
#Biweekly	Financial report	Board approval
#Quarterly	Budgeting	Board approval
#Yearly	Internal audit plus approval by the General Assembly	Closing of the year

2.3 Financial Statements

ARIS is fiscally healthy and has strongly improved financial oversight.

This has been achieved by introducing new software tools to gain more structured and fail-proof oversight over the team's finances. Furthermore, the communication channels for financial decisions have been shortened in order to increase efficiency and the teams have been given more insight into the planned distribution of incoming funds.

2.3.1 Statement of Financial Position

ASSETS *1.10.2022*	CHF
Bank account CHF	91'994.52
Cash on hand CHF	125
Cash on hand USD	364.06
Total Assets	**91'994.52**
Emergency Provisions	**20'000**

Emergency provisions are stored on the ARIS bank account and, thus, are included in the total association assets.

2.3.2 Profit and loss statement

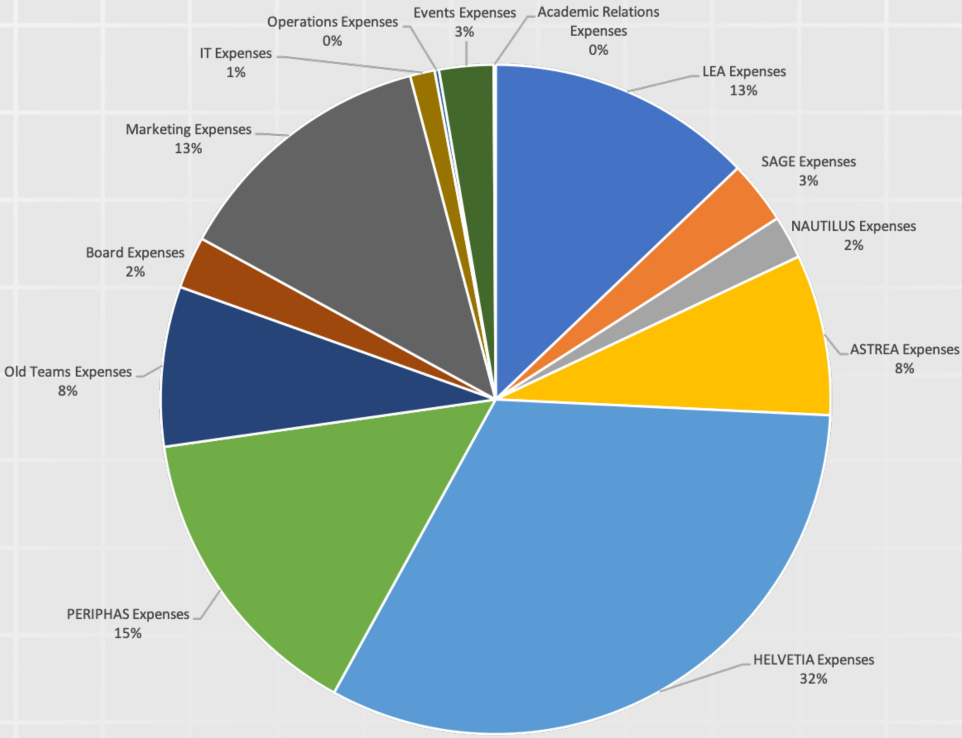
REVENUES	CHF
Merchandising	11’498.46
Commitment Fees	14’992.04
Cash Sponsoring	118’823.25
Other Revenue (corrections)	7’876.17
BARIS	739.86
Total Revenue	**153'929.78**

EXPENSES	
Bank Charges and Rounding Differences	-193.02
Total Project Expenses	**-142’850.47**
Rocket Teams Expenses	-114’934.15
LEA Expenses	-18’365.56
SAGE Expenses	-4’350.00
NAUTILUS Expenses	-2’975.00
ASTREA Expenses	-11’100.00
HELVETIA Expenses	-46’075.73
PERIPHAS Expenses	-21’035.50
PICCARD Expenses	-4’729.84
DAEDALUS Expenses	-1’314.20
PHOENIX Expenses	-4’988.32
Total Business Teams Expenses	**-27’916.32**
Board Expenses	-3’590.15
Marketing Expenses	-18’456.19
IT Expenses	-1’700.00
Operations Expenses	-300.00
Events Expenses	-3’738.20
Academic Relations Expenses	-131.78

OVERALL PROFIT (ARIS Lifetime)	CHF
Cumulated profit carried forward	20’346.54
Current year profit	10'146.43
Overall Profit	**30’492.97**

2.3.3 Financial Breakdown

80% of total ARIS cash is associated with engineering project teams. In the past year, a substantial amount has been invested again in the marketing sector. Overall, CHF 27’916.32 (20%) have been necessary to run the association and to cover the expenses of the insurance, operations and other business teams.



2.4 Outlook

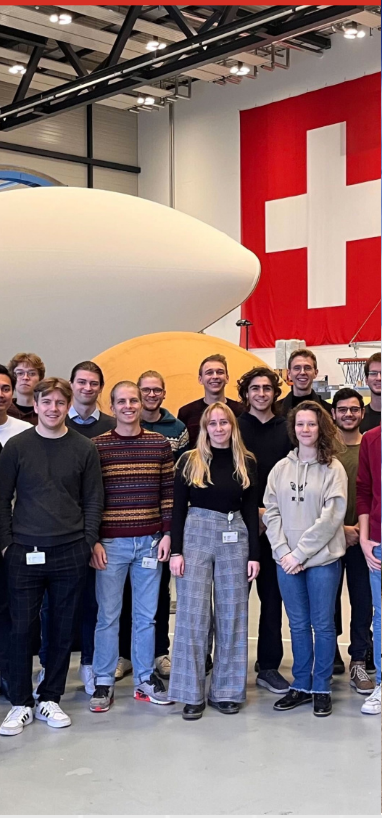
2.4.1 Key Learnings

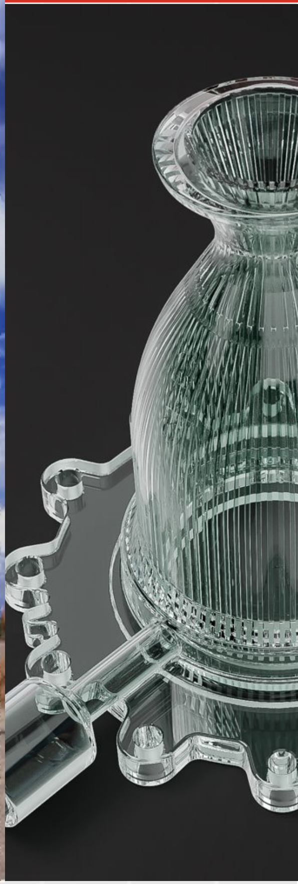
Improvements on the accounting and budgeting side have been done, especially in these 4 categories:

- A new accounting software, namely Bexio, has been set up. It ensures much higher automation and error avoidance.
- All the receipts and invoices are now safely sorted and stored in Bexio, which ensures a professional layer of security.
- Automatization and standardization of procedures is key to reduce mistakes and waste less time.
- The concept of “Available Funds” has been introduced, which incorporates a fluid prediction and distribution of available cash which has not yet been provisioned. With this the teams have a constant oversight of their available funds even before requesting them.

2.4.2 Emergency Provisions

ARIS has planned to establish an emergency reserve fund to cover unexpected necessary spending that would be increased year by year. The long-term goal is to set aside from CHF 30'000 to CHF 50'000. At the end of the 2021/2022 financial year, ARIS has succeeded to further increase the provisions to CHF 20’000.





3. ARIS Organizational Changes

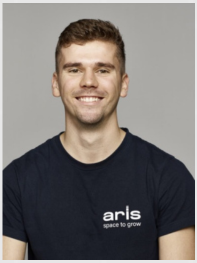
3.1 ARIS Association Board 2021/22

ARIS is a non-profit association and a board is legally required. It consists of seven members which are overseeing all association activities by leading the association executively and strategically. At the GA on November 1st 2021, several alterations took place:

- Michael Kerschbaum, former Head of Academic Relations, took over the role as President from Manuel Gerold, who left the ARIS Board.
- Adrian Fuhrer, took over the role as Vice President from David Häusermann, who left the ARIS Board.
- Marco Trentini, former Head of Legal/Admin, took over the role as Treasurer from Cesare Primultini, who left the ARIS Board.
- Aaron Ehrat took over the role as Head of Legal/Admin.
- Xeno Meienberg, took over the role as Head of Academic Relations.
- Alex Brandes took over the role as Head of Industry Relations from Otso Gächter, who left the ARIS Board.

Michael Kerschbaum
President

Adrian Fuhrer
Vice-President

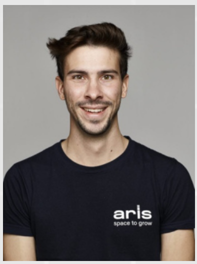


Alex Brandes
Head of Industry Relations

Aaron Ehrat
Head of Legal/Admin

Lukas Hauser
Head of Strategic Development

Xeno Meienberg
Head of Academic Relations



Marco Trentini
Treasurer

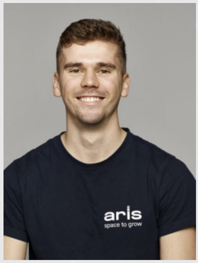
3.2 ARIS Association Board 2022/23

At the general assembly on October 29, the assembly voted to disband the Board position for Head of Strategic Development. We thank Lukas Hauser for his contributions as a member of the ARIS Board. The following members have been re-elected:

Michael Kerschbaum	–	President
Adrian Fuhrer	–	Vice President
Marco Trentini	–	Treasurer
Aaron Ehrat	–	Head of Legal/Admin
Alex Brandes	–	Head of Industry Relations
Xeno Meienberg	–	Head of Academic Relations

Michael Kerschbaum
President

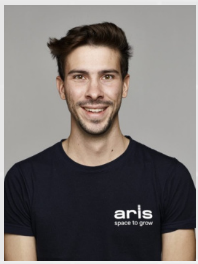
Adrian Fuhrer
Vice-President



Alex Brandes
Head of Industry Relations

Aaron Ehrat
Head of Legal/Admin

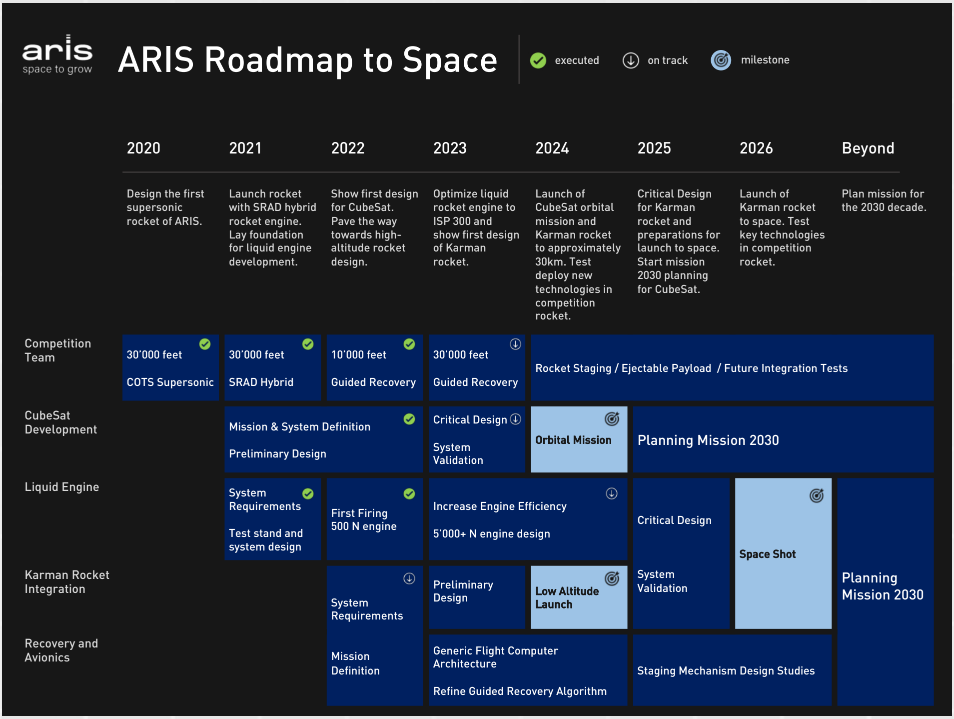
Xeno Meienberg
Head of Academic Relations



Marco Trentini
Treasurer

3.3 ARIS Roadmap – Sounding Rocket Development and Beyond

Founded in 2017 by students from ETH Zurich, ARIS until today involves more than 300 engineers, scientists and managers devising, building, and testing sounding rockets, rocket engines, CubeSats and autonomous underwater vehicles. The founding members – inspired by the many American university teams competing in building sounding rockets – set a clear goal for our association: to fly a fully student-researched-and-developed rocket, integrating an advanced rocket structure, a competitive hybrid rocket engine and a novel guided recovery system at Spaceport America Cup before the mid 2020s. The team defined a detailed timeline for the first five years of the association, paving the way towards this ambitious goal. We are proud to report that the association is on track of achieving this milestone.



At the association's initiation, however, we made clear that for us this will only be the first milestone on our journey to space: Until the end of the decade, we want to fly a student demonstrator to space. This broader approach to space science and engineering is also reflected in our 2021/2022 project portfolio, with our members for the first time working on liquid engines, CubeSats as well as autonomous underwater vehicles. As an association "from students for students", we will continue fostering ambitious goal setting and following up on these goals, true to our key values "Inspire. Engage. Build."

On track with our 2024 goal, it is the time to set a focus for what will come after having reached this milestone. The ARIS Board is eager to share its roadmap for the coming decade of our association with our partners and friends.

Our goal is clear: ARIS wants to bring an experimental payload to orbit on an in-house developed rocket by the 2030s. To that end, the ARIS Board identified three intermediate milestones:

- **2024:** Launch a CubeSat Experiment on a ride-share mission.
- **2024:** Launch a rocket to approximately 100'000 feet propelled by a liquid engine.
- **2026:** Launch a sounding rocket to the Karman line at 100km.

Undoubtedly, the targeted timeline is ambitious – especially if tackled within the scope of a student organization. It will require further workflow improvements on all levels of our organization – from HR to management, from IT to testing procedures, from documentation to securing funding. However, it is also a goal that builds up on all the technical and organizational expertise we acquired until today. Requiring contributions from all our projects it shall also serve as the main driving force of progress within our association. And most importantly, it is a roadmap that all ARIS members can associate with, true to our vision:

Contribute to the Advancement of Life and Take Part in Exploring its Origins by Developing Systems Meant for Space.

- The ARIS Vision

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