ANNUAL REPORT 2023/24

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Official annual report of ARIS for the fiscal year from October 2023 to October 2024

Issued by the ARIS association board on December 31, 2024.

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ARIS Report of Activities in 2023/24

Project NAUTILUS

In September 2023, we embarked on the next iteration of our autonomous underwater glider project, building upon the success of our initial prototype. This first iteration, which underwent rigorous testing in pools and a lake from winter 2023 to summer 2023, demonstrated the feasibility of our concept. Guided by these learnings, we established ambitious new goals for this year, including the capability to operate at depths of 1000 meters in polar regions and to conduct month-long missions covering extensive distances to gather critical data.

We initiated a concept phase to refine and redesign essential systems to meet these heightened objectives. While the software and electrical components continue to evolve from the first iteration, the mechanical elements—particularly the buoyancy control system and the hull—required a complete overhaul to withstand the extreme pressures at greater depths.

Moreover, our team expanded significantly this year. What began as a project within the ARIS Project Lab with around 10-15 students has grown into a robust team of over 40 students in 2023/24, marking the establishment of a new Robotics pillar within ARIS, broadening our expertise.

Software Team: The Software Team has been integral in advancing the software capabilities of the NAUTILUS project this year. The team's development focused on establishing a flexible and robust software platform capable of accommodating changing mission parameters. To achieve this, they implemented a two-controller system: the Primary Controller, a high-power computer designed to manage intensive computations and oversee critical mission tasks, and the Secondary Controller, a low-power device optimized for continuous runtime and handling monitoring along with simpler tasks. This foundational architecture has set the stage for further advancements, testing, and expansion of the project's software needs.

Research Module: Progress in the Research Module was marked by innovative design and engineering. The team designed a new protective shell tailored to house essential underwater sensors, complete with a modular skeleton that can accommodate various sensor types. This year, they conducted numerous hydrodynamic simulations to refine the shell's design, ensuring optimal performance and stability under water. The completion of the design phase has paved the way for the assembly of the sensor module, with plans for in-water testing in the upcoming year to validate its functionality and precision in real-world conditions.

Hull Design Team: The Hull Design Team tackled significant challenges this year as they prepared for the NAUTILUS project's operation in the harsh conditions of the Arctic Ocean. A full redesign of the UUV's hull was necessary to withstand the demanding new environment. The team opted to maintain the cylindrical shape of the hull for manufacturing ease but enlarged it significantly to accommodate an expanded mission scope. Titanium was selected

for its ability to withstand up to 100 bar pressure at depths of 1000 meters. The redesign also involved developing new sealing mechanisms to ensure the structural stability and waterproofness of the hull. A series of rigorous tests is planned for the next summer to validate these innovations.

CU System Development (HS23 and FS24): This period saw the CU System Development team focusing on defining and refining the buoyancy control systems for the UUV. Initial phases involved detailed analysis and selection of components, integrated into CAD models for precise engineering. Challenges such as internal bureaucracy, sponsorship issues, and technical difficulties delayed the test setup initially planned for the end of HS23. However, by FS24, after solving critical issues like reservoir pressure, the team achieved significant milestones by finalizing the test setup and initiating component testing. This progress is crucial for ensuring the system's readiness for integration and operational testing.

System Engineering: Over the past academic year, the two system engineers have worked on shaping the system as a whole. Their focus was on ensuring that the different subsystems would work together seamlessly and on defining the goals and requirements needed for the successful deployment of the UUV.
In addition to their technical responsibilities, the system engineering team also supported the project manager in turning our system's vision into reality. This involved tasks such as representing the technical aspects of the project in meetings with potential sponsors and helping to organize team events.
Looking ahead to the coming year, the system engineering role will pivot towards ensuring that all teams have the necessary resources to build their subsystems and conduct tests. They will also ensure that new designs and tests continue to meet the requirements and that all subsystems can work together as needed for a successful mission.

Financial Expenditures:

The table below presents the detailed financial expenditures for each team over the academic year 2023/2024, illustrating the ongoing and anticipated costs associated with the project's development.

Team	Current Expenses (CHF)	Upcoming Expenses (CHF)
SW & ET	Controllers: CHF 220	Depth Sensors: CHF 1'500
SW & ET	Courses: CHF 120	Doppler Velocity Logger: CHF 80'000
Research Module	CHF 0	Enviromental Sensors: CHF 10'000
Hull Design Team	CHF 0	Grade 6 Titanium: CHF 20'000
CU System	Vacuum Pump: CHF 581.67	Hydraulic Components CHF 3'000

Business Team

The business Team grew from 6 to 20 Members in the course of the year. The creation of a new PR department and Sponsoring Team as well as the development of a corporate identity and Brand strategy were at the core of this year's developments. Our outreach on social media increased by 140% compared to the year prior.

Successes of the Business Team in 2023/2024:

- Organizing the first Swiss Student Space Summit in July 2024 (around 300 participants)
- Organization of a joined Open Day at IPZ with AMZ, Cellsius and Swissloop for potential focusproject students and freelancer
- Social media growth by 140%
- 2024 social media advet alender
- New and innovative Corporate Identity
- Stabilized growth of business team
- Most intedisciplinary Team amongst ARIS teams
- Organizing the first Swiss launch since 3 years with project NICOLLIER
- Design of new merch items

Overall the Business Team has had a successful project cycle and is well prepared to support our projects' successes in the future as well.

Project HELIOS

Project HELIOS was the third liquid rocket engine project at ARIS. This project came in the continuity of project LEA 21/22 and project PROMETHEUS 22/23. The main goal of HELIOS was to focus on research and development based on the existing engine and test facility, advancing ARIS' capabilities and system understanding through scientific evaluation and selective improvements. HELIOS identity subscribed to ARIS' bigger goal of reaching the Karman line by working towards an LRE powered rocket. The three main goals were :

1- To conduct an engine parameter study

2- To improve throtthling capability and accuracy

3- To build a sound suppression system

The team was made out of around 30 ETHZ students but from various field of studies such as mechanical engeneering, computer science or geospatial and all at a different stage of their studies from bachelor students to master students and even PhD. They were recruited at the start of the fall semester 2023 and the team started working after the project kick-off end of October 2023. Every member worked as a freelancer for the project, meaning they didn't receive any credits for their work.

Figure 1: Picture of HELIOS team

The team was initially structured in four sub-teams : The engine team was handling the paramerer study as well as building the sound suppression system ; PSS (Propellant Supply System) whose main task was to do maintenance on the already two year old trailer and keep the piping system which supplies the engine in LOX and ethanol in good working conditions ; Software and Hardware worked as a duo. Software providing reliable plots based on tests data to make data analysis faster and easier and Hardware keeping cables and sensors in operating

conditions. The project was managed by the project manager, the system engeneer and the four sub-teams leaders who met once a week for a management and interface meeting where inter-sub-teams topics were discussed. The interface meeting hold a great importance during the second part of the project when the testing campaign started to keep track of the state of the trailer.

Since the team started to work two months in the semester the two remaining months were mainly used in understanding the system and the procedures to safely test. This already was a great challenge. Firstly because the trailer was unherited from previous years and wasn't build by the HELIOS members hence it took them some time to understand such an advanced and complicated technology as liquid rocket engine especially since most of the members were new to ARIS and rocket science. Secondly because HELIOS wasn't a focus project as PROMETHEUS meaning the members also had to study next to the project and couldn't invest as much time and effort as their fellow PROMETHEUS colleagues. By the end of the first semester all the members had achieved a great understanding of the system on top of which the engine team also had finalized the design of their sound suppression system and it was sent to manufacturing over the winter break.

Figure 2: Team after first firing

The spring semester started strong with the presentation of HELIOS testing timeline end of february and testing started by end of march with water and LOX coldflows. The first HELIOS firing happened on may the 18th after some delay due to valves issues. However the PSS team eager to see the firing happening quickly were on deck and solved the problem. Once we started firing the semester soon came to an end and we only were able to fire thrice resulting in only one readable data point for the parameter study. On the otherhand we successfully managed to test the new sound suppression system but unfortunately didn't get the time to test it during a firing. The second semester also saw the creation of the throttling taskforce made

out of members from PSS and Software to handle HELIOS trottling goal. An open-loop and a close-loop controller came out of this taskforce. The open-loop one was tested during a water coldflow but none of them could be tested during a firing.

Figure 3: Sound supression system

Over all HELIOS duration some goals weren't achieved, some were achieved to a certain extend but this isn't what should be taken out of this project. The knowledge transfer of such an highly technical project was indeed underestimated which took the team so much time to start testing but they still managed to fire which is in itself a victory. HELIOS couldn't subscribe more to ARIS' philosopy. Not because it worked towards developing an ARIS LRE powered rocket but because it gave engeneer students who knew nothing about rocket science let it be LRE space to grow and brought them to the level of knowledge and technical experience to safely fire one.

ARIS new project cycle has already begun and is already in full swing however former HELIOS members are still at the heart of ARIS' activity either by directly using the knowledge they have learned this year in a project they are active members of or by sharing it with others by advising new and ambitious ARIS projects.

Project NICOLLIER

Project NICOLLIER was established as the 2023/2024 Competition Team of ARIS (Academic Space Initiative Switzerland). Named in honor of Claude Nicollier, Switzerland's only astronaut, the team draws inspiration from his legacy, aspiring to pursue innovation and excellence in every endeavor. Building on ARIS's foundational knowledge, the team set out to design a pioneering rocket.

« I am honored to have my name associated with this project – Go ARIS! »
- Claude Nicollier

The Team:

NICOLLIER was initiated as a freelance project, uniting 43 members from diverse nationalities, universities, and backgrounds, all bound by a shared passion for rocketry and innovation. True to the spirit of ARIS, the team was a space to grow. Members were not selected based on perfect résumés but for their curiosity, willingness to work in a large team, and determination to challenge themselves to achieve greatness.
Remarkably, only two of the 43 team members had prior experience at ARIS or in rocketry. This lack of experience posed challenges, but the team was supported by the expertise of ARIS alumni, the academic resources of their universities, and the innovative ecosystem Switzerland offers. Combining curiosity, optimism, and available knowledge, the team transformed this inexperience into a strength. They not only learned and grew together but also developed cutting-edge technology that gained worldwide attention.

Figure 4: Source: CNN

The Rocket:

Most teams in ARIS, like NICOLLIER, have the opportunity to decide the their own goals and design philosophy. During the process they are supported by alumni. With this the team can develop the technologies they view as the most promising. It also fosters a connection between the members and the project.
Team NICOLLIER decided to implement and majorly improve the Guided Recovery desined by three teams between 2020 and 2023. The project should also include multiple other technical innovations. All those were implemented with a design philosophy focused on safety, reliability and reusability.

Figure 5: NICOLLIER rocket

The rocket is propelled by a commercial off-the-shelf (COTS) solid motor. The motor enables a full system test during a launch. This is the most reliable way to test that all systems can withstand the forces of a launch and that the systems function as intended. The team chose the COTS motor because of ist simplicity and easy implementation. With this the team could focus on the development of the other technologies while ensuring a launch.

In spaceflight one of the most important aspects is accuracy. For this the rocket includes an airbrake section just above the engine fairing. These airbrakes are metal plates that are moved by electric motors and steered by the board computer. The plates drastically increase the drag of the rocket when extended. Using this concept the rocket can be navigated to a precise, predetermined altitude. Throughout the flight the computer uses the telemetry data to calculate the ideal extention of the airbrakes.

All sections of the rocket are connected by metal couplers which are glued to the carbon fiber/fiberglass fairings. This builds the outer shell of the rocket. The couplers also provide a place for venting holes, safety pins, power supply adapters and cameras. The only fiberglass fairing is around the avionics stack. Carbon fiber shields from electromagnetic radiation which would interrupt the connection between the stack and the ground station when used in the fairing.

The avionics stack is the brain of the rocket. It houses all printed circuit boards (PCBs), collects and transmits data and steers the motors of the rocket. The stack has a modular design

enabling us to switch dysfunctional PCBs in seconds. It is also capable of adding new boards to operate new systems which makes it ideal for long term use.

Above the avionics section is the Guided Recovery System. This uses a ram-air parachute which is attached to the rocket and steered by two electric motors. This system is deployed as soon as the nosecone is disconnected using a new mechanical separation system. As soon as the parachute is open the rocket steers itself down to a targeted landing position. There it is fully recovered.

At the top of the rocket is the nosecone which is screwed to the top part of the mechanical separation system and holds two payloads. Those payloads are Can Sats which were developed by two student teams and were flown with the rocket to conduct measurements.

Figure 6: NICOLLIER Rocket at CNN video day

Source: CNN

The Project:
The project kick-off was in September of 2024. Back then the team only consisted of 25 members but the number grew over time.
The first task was to define the mission that the team wanted to achieve during the project. For this the team came together in multiple full team meetings and planned the systems in subteam meetings. In October the mission was presented to the alumni on the System Definition Review (SDR). There they received the feedback and were able to finalize the mission statement.
With the mission clear the team started working day and night to design the rocket, starting from the general parameters of the rocket up to the smallest resistors sitting on the PCBs. The first design was once again presented to alumni on the preliminary design review (PDR) around a month after the SDR.
With the input the team pushed through to create the final design and present it at the critical design review (CDR). This large push enabled the team to send out all orders to sponsors while the team went into exam break.

With multiple parts now at the hangar, the exams completed and a few days of rest the team started into the manufacturing phase in mid of february. Here the first in-house produced parts

like fairings and electronics were manufactured. The members also started to assemble the systems for the first time and to conduct tests on a
subsystem level. Any necessary adjustments were made and send to our sponsors.

The work was aimed towards the first full system test: the droptest. In these tests
the rocket falls from a helicopter and the self steering capabilities are tests.
After many droptests cancelled due to the horrible weather, the first drop was conducted on the 13.06.2024 on the scenic shooting range Wichlen, in the swiss alps. The second one followed soon in another valley near Gadmen. Both tests were a complete success and the system behaved exactly like expected, the controller was stable and the rocket adjusted well to the wind. In the second droptest we also had the great pleasure of being filmed by the Cable News Network (CNN).

Figure 8: Drop Test Video day CNN

Source: CNN

Figure 7: Drop Test NIC test day CNN

Source: CNN

At the same time the team did not only test their system but also themselves. For the project's success multiple so called dry runs were conducted. In those the full system is assembled and a launch is simulated. The test are crucial to test the full functionality of the system, test launch procedures but most importantly test how well the team deals with the stress and non nominal situations. Up until the launch a total of four droptests were conducted. Three of them before and one after the exam phase.

After the summer break the team came back together to prepare for the launch in switzerland. This launch was finally completed on the 16.11.2024 in Wichlen, Switzerland. The team started with the preparations early in the morning. At 1:00 around 200 visitors joined in person and up to 400 people followed the launch online.
And around 3 o'clock local time, while the heart of the visitors stopped, NICOLLIER lifted of the ground, flew to it's targeted apogee, deployed the main parachute and landed safe and more importantly completely intact.

Figure 10: NIC Launch Nov. 16 2024

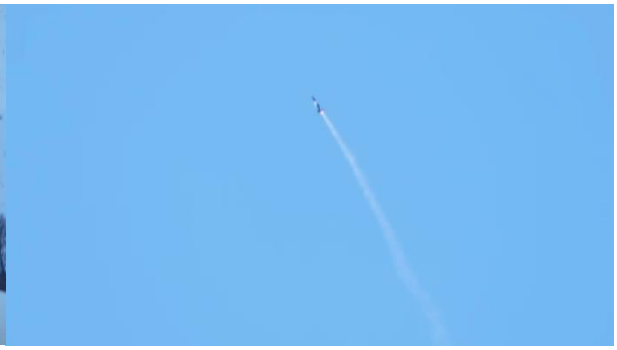

Figure 9: NIC Launch Nov. 16, 2024

Overcoming difficulties:

But the path was not as easy as it sounds. The team had to face and overcome major probelm surrounding sponsors and parts. Furthermore after months of hard work and careful preparation the team had to cancel a total of 11 droptests this year because the extrem weather did not allow the tests to be conducted safely. The team had to come back from being rejected by EuRoC 2024 and had to organize their own launch. And most importantly they had to do all of this as freelancers while studying full time and many also working to finance their life in switzerland.

It was a extremely challenging time for the team. At the end however the massive media attention of seven (and growing) news channels including two shows at CNN as well as the massive support by the public pushed the team to achieve what they set out to do. The team pushed the boarders of what is possible both on a personal and team wide level. The people who started the project together grew together as a team. Every single member gained memories and experience that will last a lifetime.

And with the findings of the ground recovery we can happily declare that our project achieved exactly what it wanted and was a complete success.

Like Claude Nicollier said it himself «Go ARIS» and «Go NICOLLIER!»

Figure 11: Recovery of NIC Rocket at launch Nov, 16, 2024

Project SAGE

The SAGE CubeSat Mission

The SAGE CubeSat Mission has four main objectives:

- to design and operate a satellite as an educational project
- to study the aging of human cells under zero gravity for future space exploration
- to operate an amateur radio payload and an ETH developed GNSS module
- to test and validate custom ASIC developed at the Integrated Systems Laboratory at ETH

SAGE is designed with a focus on in-house developed modules, focusing on the On Board Computer, Communications and Biological Payload as well as the Software for Flight and Ground, which are complemented by flight-proven components to decrease the project risk.

Bringing Science to Space

The CubeSat Mission SAGE investigates the aging of human cells in the microgravity conditions of low earth orbit. With the growing significance of space exploration, understanding the impact of space on the aging of the human body is crucial. By keeping a state-of-the-art human model system alive and in optimal conditions inside the payload of our satellite, which usually requires a complex medical laboratory set up, we are able to gather scientifically relevant data directly in orbit.

The Team

SAGE is a diverse team consisting of over 80 ETH, HSLU, and ZHAW students from various engineering and science disciplines. What brings us all together is our passion for space and contributing to novel technology for small satellites and cutting-edge research in different fields. We do all of this with a common goal: Launching and operating our very own satellite and thus, inspiring the next generation of aerospace engineers and professionals.

Activities in the academic year 23/24

Between September 2023 and August 2024, SAGE has completed the following Milestones:

- Continuation of the development of in-house components.
- Clearing action items from the RIDs from the Baseline Design Review with ESA.
- Holding our Critical Design Review with Swiss Industry Experts..
- Had our Final Design Review with ESA, which can be seen as a sort of extended CDR.
- Sustainably kept the team size of around 80 motivated students.
- Completed over 10 theses together with different institutes from ETH.
- Raised the TRL Levels of several components.
- Started testing components on the FlatSat and in the Vacuum chamber.
- Participated in many events around Switzerland and Europe.
- Organized several events with academia and industry to showcase the progress of the project.

What's next

In 24/25 SAGE will finish the development of all components, and start with the system integration. Following the system testing at FlatSat Level, a QM will be assembled, which will be externsively tested. Further all software development will be completed with the QM. In parallel mission planning and mission operations will be developed and prepared for the launch. Following the QM testing, the FM will be assembled, tested and made ready for launch in 2026.

Figure 12: SAGE visiting DLR

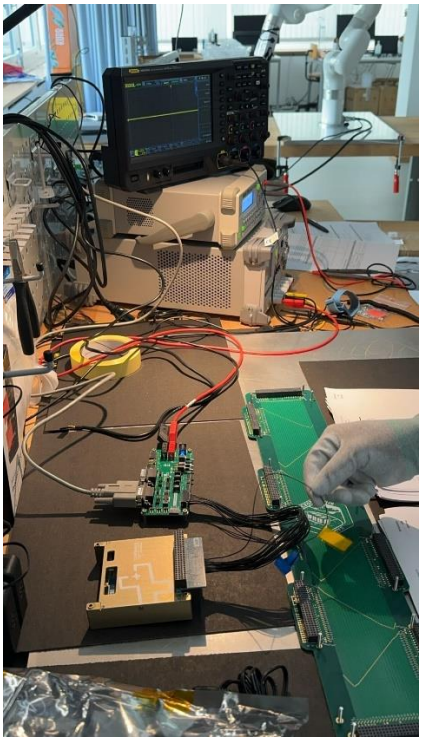

Figure 13: Flatsat testing of SAGE

Figure 16: SAGE at Verkehrshaus Luzern

Figure 14: SAGE represented at IAC Milan

Figure 15: SAGE at ESA for the final design review of the “Fly your Satellite” Challenge

ARIS Financial Report 2023/24

Financial Report Executive Summary

We are pleased to report that ARIS has successfully maintained a stable financial position during the 2023/24 fiscal year.

With total expenses of CHF 171,329.08 and net revenue of CHF 150,255.72, the fiscal year concluded with a net loss of CHF 21,216.72.

This loss is primarily attributable to our long-term projects. While we secured sponsorship early on, these projects have now entered the construction phase, which necessitates significant additional funding.

The breakdown of cash expenses by individual teams is provided in the following table:

SAGE	CHF 71’178,75
NAUTILUS	CHF 139,83
BERNOULLI	CHF 19’578,88
PROMETHEUS	CHF 15’829,20
ODYSSEY	CHF 0,60
COLD	CHF 225,70
NICOLLIER	CHF 13’321,76
HELIOS	CHF 4’445,95
PERSEUS	CHF 723,70

Although we successfully provided the necessary funding to support the technical teams during the previous financial year, challenges persist in securing sufficient budgets for the longer-term teams now in their technical phases.

A primary focus for the current financial year is to optimize our spending and increase cash sponsorship to the association. This will improve our financial position and enable us to continue supporting the technical teams as they take on increasingly complex projects.

Overview

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.

Process and Oversight

The ARIS board, management and internal auditors provide financial oversight throughout the whole association year:

- Continuous daily updates and tracking of expenses through the association's treasurer.
- Weekly review of team needs as part of the association management meeting. Teamleaders review the state of finance to spot mistakes and pose questions.
- Bi-weekly review of the financial state of the association by the board during board meetings.
- Yearly book auditing, approval by internal auditors selected by the general assembly.