

The background of the cover is a composite image. The left side shows a green, grassy hillside. The right side, separated by a diagonal blue line, shows a close-up of a rocket engine or space hardware with a bright orange glow from the sun or a fire. The ARIS logo is at the top center.

aris
space to grow

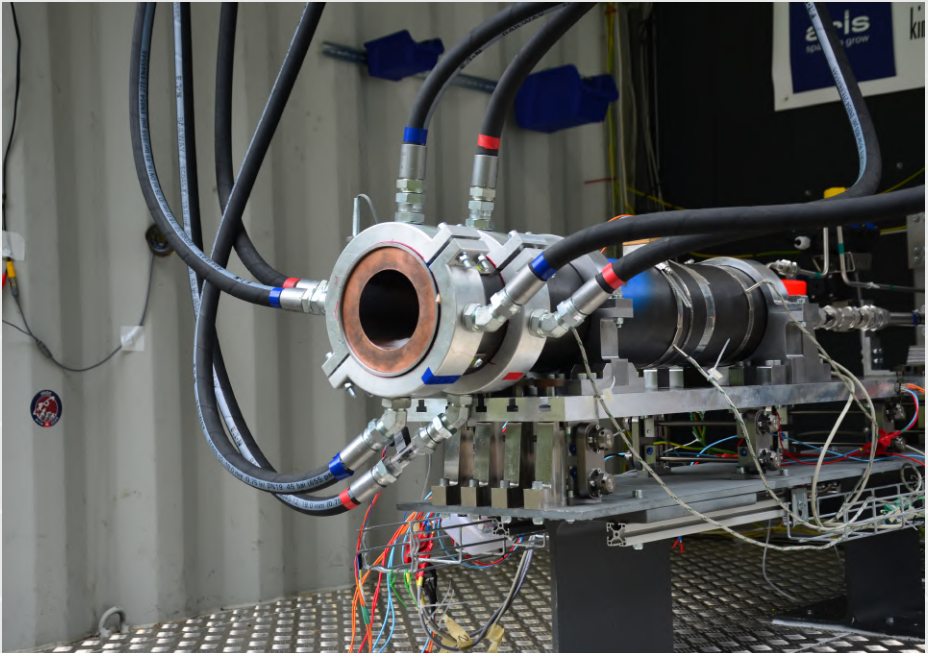
ARIS Annual Report 2019/20

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

inspire.



engage.



build.



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Official Annual Report of ARIS for the fiscal year from October 2019 to October 2020

Issued by the ARIS association board on November 9th, 2020

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President

David Häusermann
Vice President

Evgeniya Vorobyeva
Treasurer

Otso Gächter
Industrial Relations

Andrea Schorn
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Marco Trentini
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2020 – A year of firsts

EXECUTIVE SUMMARY

With three technical projects up and running from September 2019 on, the aim is again set for the stars. Project RHEA, is about to conclude their Hybrid Rocket Engine (HRE) development with a first firing campaign. In project EULER, an interdisciplinary team of 35 students aim for the development of the first supersonic sounding rocket of ARIS. And project IRIDE, the first ETH Focus Project organized by ARIS, already starts building up on the knowledge of RHEA and are eager to develop the first flight-scale engine.

An incredibly successful first phase of the projects by passing each technical review with valuable feedback, could be concluded by the phenomenal first ignition of an ARIS developed HRE. With a measured peak thrust of more than 1'000 N project RHEA marks the beginning of the ARIS hybrid era.

Despite a highly turbulent year full of unknowns due to COVID-19, both project EULER and project IRIDE keep the focus on their mission at any point in time. At ARIS safety is our number one concern and with the flexibility of our members and partners the timeline of the projects could be adapted efficiently to comply with all regulations.

Project EULER successfully co-hosted the first sounding rocket launch in Wasserfallen, Lucerne, together with the EPFL Rocket Team (ERT). Aiming for 1435 m, the sounding rocket EULER reached an apogee of 1465 m, resulting in a deviation of only 2 % thanks to the autonomously actuated air brake system.

Following the footsteps of their predecessors, project IRIDE raised the testing and safety standards at ARIS again significantly with their HRE testing campaign. 13 successful hot firings generated an incredible amount of data with firing times of up to 16 s and a peak thrust of close to 8'000 N.

These achievements are only possible with an immense amount of team work within the association and within our partner network. We are looking forward to the upcoming endeavors and want to thank every friend of ARIS for your continuous support.

Academic Partners

ETH zürich

Lucerne University of
Applied Sciences and Arts

**HOCHSCHULE
LUZERN**

Technik & Architektur

zhaw

School of
Management and Law



University of Zurich ^{UZH} UZH Space Hub



Laboratory of
Composites Materials
and Adaptive Structures



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Physik-Institut



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WIKAL

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HIGH PERFORMANCE MACHINE TOOLS

SINTRATEC

amsler
key up
Swiss machined
plastic parts

CHROMOS **VIDEAL**

KIFA



1. ARIS Report of Activities in 2019/20

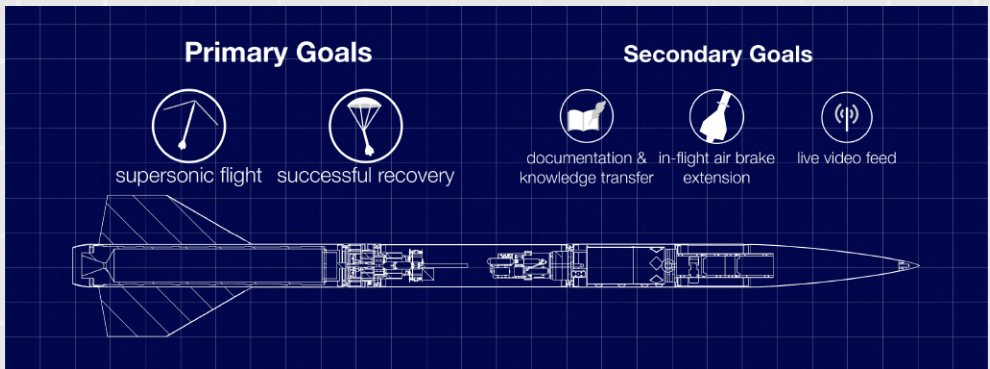


In 2019/20 ARIS tackled and overcame a number of challenges posed by ambitious goals and external factors. This fiscal year stands under the sign of firsts with additional incredible progress further increasing and unifying the safety standards within the association: 80 ARIStronauts developed a neatly-engineered sounding rocket and a sophisticated Hybrid Rocket Engine (HRE), attracted top-of-the world space explorers, and carried their passion and courage into the world.

Today we can proudly say that ARIS won three prizes in three years, receiving the award for technical excellency at the European Sounding Rocket Competition (EuRoC). Furthermore, a successful first HRE test firing has been conducted, that paved the way for a successful testing campaign for the second, flight-scale engine. All these achievements result from combining students and initiative partners that are active beyond the ordinary. Thank you all for achieving these big steps together!

1.1 Project EULER aims for a supersonic flight

Building on the strong heritage of the previous sounding rockets TELL and HEIDI, project EULER set out in September 2019 to build ARIS' first supersonic rocket and reach the target apogee of 30'000 ft at the Spaceport America Cup 2020 by means of a solid commercial off-the-shelf motor. As payload, an "antimatter fuel tank" which stores positrons in ultra-high vacuum in a 4U cube-sat format was developed by an ARIS alumni in the scope of his Master's thesis.



The team of 32 students from 8 different fields of study and 8 different nationalities started into the project by thinking in-depth about the mission ahead and the requirements to the system which were presented at the System Definition Review (SDR) beginning of October 2019. During the subsequent design phase, concepts were evaluated and refined with input provided by a review board of experts from industry and academia during the Preliminary and Critical Design Reviews (PDR and CDR) before Christmas.



Over Christmas, the project went into the manufacturing phase. Aluminum parts such as the air brakes or the coupler system were manufactured by external partners, and the carbon and glass fibre fairing was produced in-house at ETH facilities. The recovery system was subjected to tests and the rocket was almost ready for lift-off two weeks before the planned maiden launch mid March 2020.



With the structure nearly finished, however, the team's efforts were put to a sudden halt as all ETH facilities closed as a reaction to the ongoing SARS-CoV-2 pandemic. Having no access to essential manufacturing infrastructure the team had to cancel the launch. Shortly after that, ESRA announced the cancellation of the Spaceport America Cup 2020.

With the main goal for Project EULER being left unreachable the team was forced to re-evaluate their mission objectives. The team unanimously decided that the new main goal was to launch ARIS' first supersonic rocket. At the same time, the team made use of the additional time and organized the first independent launch in Switzerland, together with the EPFL Rocket Team (ERT).

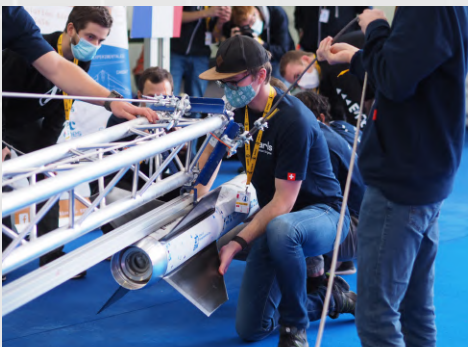


As soon as the facilities opened again in June, the team finished the last manufacturing steps and successfully concluded the testing campaign. On July 4th, 2020 EULER successfully lifted-off the launch rail in Wasserfallen, Luzern and had a stable subsonic ascent to 1465 m. By means of extending the systems air brakes — for the first time in a Swiss competition rocket — the rocket missed its target apogee of 1435 m by less than 2 %. Unfortunately, EULER's redundant recovery systems experienced a dual-failure resulting in an unsuccessful recovery of the vessel.

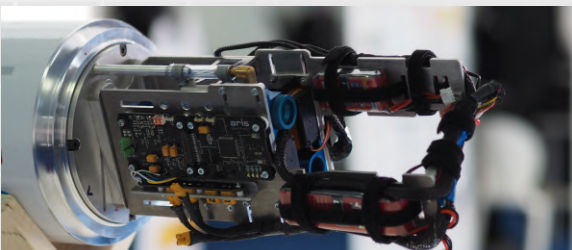


In the following root cause analysis of the recovery failure supported by our industry and academic partners the team worked on improving the reliability of the system. Everyone continued pushing towards the goal of launching EULER supersonic — an endeavour made possible by yet another first in ARIS' history.

With Spaceport America Cup 2020 cancelled, in a joint effort several European teams started looking for alternative opportunities of launching their rockets. The eagerness of the students paid off and resulted in the first edition of the European Rocket Challenge (EuRoC) hosted by Portugal Space and the Municipality of Ponte de Sor. Born in the spirit of the Spaceport America Cup, EuRoC allows student teams to compete in launching rockets from European soil.



For EuRoC 2020, student teams from Denmark, France, Germany, Austria and Switzerland were invited to Ponte de Sor. Arriving in Portugal, the team immediately started getting ready for the launch day, configuring the flight computers and running final tests on the electronics systems. Despite all the preparations and testing of the system, however, both recovery flight computers showed anomalous behavior during assembly on the launch day. The students pushed hard for getting the hardware flight ready within the limited launch window, but in the end made the collective decision to not give EULER a go for launch due to flight safety concerns.



While the scrubbed launch came as a shock to the team, the technical jury at EuRoC recognized the professionalism with which the team handled this difficult situation, as well as the overall technical quality of the rocket with an award of Technical Excellence.



To allow the next teams to build up on our learnings, several members of team EULER continue to work within ARIS as coaches, passing on the knowledge they gained throughout the past year. The turbulent but nonetheless successful year let us grow as a team and develop invaluable skills for future endeavours.

Richard Boell
Michael Kerschbaum
Nathanael Köhler
Benjamin Baumgartner
Laura Enriquez Vidal
Paviththiren Sivasothilingam
Maximilian Leeb
Paul Prantl
Silas Fiore
Emre Elbir
Charlotte Jacquet
Fikru Tiruneh
Ludwig Luz
Giona Sala
Simon Götti
Roman Möckli



Lukas Rother
Linus Stöckli
Luka Milanovic
Severin Meyer
Dario Tscholl
Maximilian Stölzle
Sean Bone
Tun Kapgen
Christoph Domenig
Maurice Ottiger
Luca Jost
Jonas Binz
Nemanja Stojoski
Imre Kertesz
Simone Gervasoni
Viviane Potocnik



1.2 Project RHEA - ARIS' first Hybrid Rocket Engine

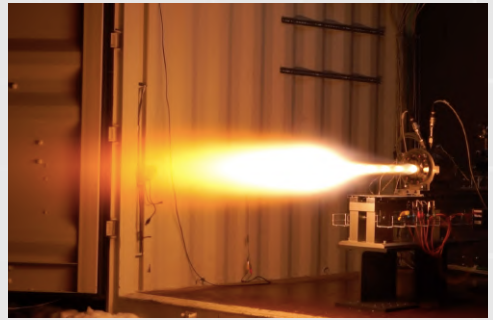
After 15 months of preparation, project RHEA was shortly before completion. The firing of ARIS' first student researched and developed hybrid rocket engine found its splendid pinnacle in a static firing test providing a peak thrust of 1253 N and a firing duration of 4 seconds.



Starting at the beginning: the team, composed of 9 students had the dream of a fully self-developed sounding rocket by building and testing ARIS first hybrid rocket engine together with its infrastructure. After defining the system, finishing the design, getting it reviewed by experts from academia and industry, the parts got manufactured. In the course of time did not only the engine hardware arrive for assembly at the hub, so did the shipping containers, providing the test stand, as well. The 10 ft and 20 ft shipping containers needed to be adapted in order to accommodate the engine with its temperature and pressure sensors on the test bench in the first compartment, the fluid supply system including the liquid oxidizer in the second compartment and the DACS ensuring data processing and data storage in the third compartment.



After having completed the test infrastructure, the containers were shipped to the test location in Ochsenboden. The team members step-by-step moved closer to the firing by weekends of dry running the system, component-wise and then combined functionality checks and successful cold flow tests. Then, on the late evening of December 8, 2019, it was time to set the final countdown. The team was waiting inside the bunker, always having an eye onto the engine through narrow viewing slits. “5,4,3,2,1,ignition ...!” First sparks were visible at the nozzle exit, suddenly marvelous shock diamonds appeared in the field of view and then night was turned into day again. A full success!



With these tests, project RHEA set the foundation for future hybrid rocket engine developments providing a test infrastructure expandable to a thrust up to 20 kN. The focus project IRIDE developed then a more powerful engine and extended the test infrastructure, bringing ARIS one step closer to integration of the engine into the rocket.

Andrea Schorn

Andreas Stankowski

Anushka Gaikwad

Christoph Germann

Clément Stoquet

David Martinez de la Cruz

Davide Frey

Filip Lolland



Kujtesa Q Kryeziu

Lukas Hauser

Marco Trentini

Maximilian Leeb

Nicolas Streit

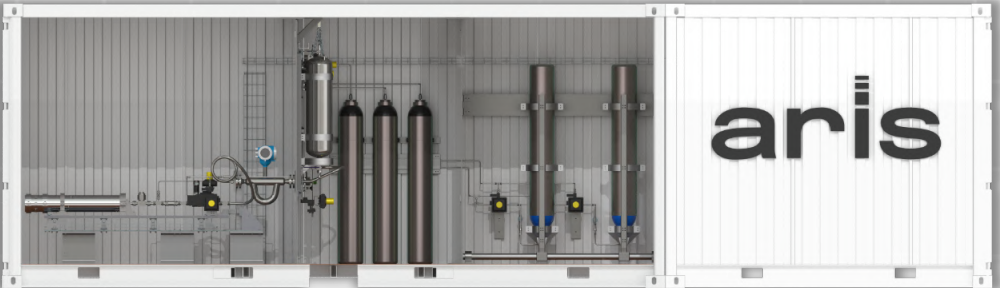
Richard Wadsworth

Shady Elshater

Sotiris Catsoulis

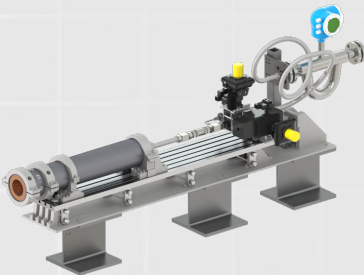
1.2 Project IRIDE goes full throttle

September 16th, 2020 marked the start of the first ETH Focus Project organized by ARIS. The successor of project RHEA aimed to design and develop a 5 kN SRAD hybrid rocket engine, capable of lifting future ARIS' sounding rockets to 30'000 ft. Under the supervision of Prof. Lino Guzzella, Bruno Berger and three coaches, a team of 8 mechanical engineering students decided to invest their third year of bachelor studies to dive deep into the development of a rocket engine.



The project started with a clear goal: build a hybrid rocket engine capable of providing a peak thrust of 5 kN for a burn time of 10 s.

With only two years of theoretical knowledge and no practical experience, but with a lot of motivation and with the awareness of being able to count on the advices of project RHEA, the team started by looking into the current state-of-the-art rocket engine designs and by thinking about possible innovative solutions.



Thanks to an experienced review board and a constantly growing list of ARIS alumni, the team received valuable feedback at the Preliminary Design Review (PDR) and the Critical Design Review (CDR). During these first phases, the engine and fluid supply designs were implemented in CAD and verified through FEA-simulations, and the first version of a control and data acquisition system was developed.

After a long manufacturing phase, during which over 250 parts were manufactured by six different partners for a total of several hundred hours of machining time, the team started assembling the system.



During this period, the team also performed subsystem validation tests, namely several carbon dioxide cold flow tests and igniter tests, with a break of over two months in between due to the coronavirus outbreak, which heavily affected the overall timeline of the project, but had no influence on the project goals and on the motivation of the team.



The assembly phase saw its conclusion at the Readiness Review (RR) in the beginning of July. Many advisors followed the review, remotely or in person, and gave crucial feedback before the start of the testing campaign, planned for the beginning of September.



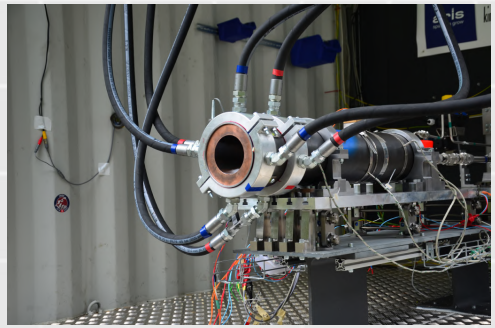
3.. 2.. 1.. IGNITION

Like a thunderstorm on a summer evening, the IRIDE engine roared for the first time on Friday, September 11th at 19:25, generating over 6'700 N of peak thrust and leaving the entire team, watching eagerly from the bunker, in awe.



Describing the feeling of seeing 12 months of hard work condensed in 2 s of firing is impossible.

As they usually say: let the pictures do the talking!



The largest testing campaign in ARIS history in numbers: Over a period of about a month, 19 firing tests across 10 testing days were performed. Of those 19, 12 were successful. The firing duration varied between 2, 5, 9, 12 and 16 seconds. The peak thrust was of 7'994 N, reached during a 5s test using an updated version of the showerhead injector.

The last important milestone of the project, was the conclusion of the final report, laying the foundation for future hybrid rocket engine developments. The first step of the legacy is project DAEDALUS, the focus project which will build upon the IRIDE engine to propel next year's ARIS sounding rocket to 30'000 ft.



Felix Winghart
Ianco Cregut
Julius Wymann
Mirela Minkova

Pascal Müller
Philip Wolf
Shady Elshater
Stefan Schmid



2. ARIS Financial Close Report 2019/20



2.1 Financial Report Executive Summary

ARIS is in good fiscal shape and has achieved all its financial goals.

The total cash expenses for 2019/20 amount to CHF 41'645 – approximately CHF 30'000 less than in 2018/19. Project EULER closes the year with CHF 19'942 excluding value-in-kind sponsoring with expected upcoming expenses of approximately CHF 20'000 in the next financial cycle. This value is approximately CHF 23'000 less than budgeted, again without value-in-kind sponsoring. The main reason for differences between budgeted and actual cash expenses comes from the extraordinary effort of EULER and Sponsoring teams in closing numerous value-in-kind funding deals.

Project RHEA contributes to the ARIS cycle 2019/2020 with additional CHF 10'286, closing its finance with CHF 22'400, which is significantly less than budgeted due to increased value-in-kind sponsoring acquired during the project.

The emergency funds has been increased twice in cycle 2019/2020 and amount to CHF 10'000.

The next financial year starts at CHF 19'500 already allocated for the next year expenses and CHF 48'808 are free to spend for the next year teams, including the participation of project EULER at EuRoC (Oct. 2020).

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 20,000 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.
- Plan budgets for 2020/21 cycle more accurately by using the actual expenses from 2019/20 as a benchmark. Furthermore, the financial team should work closely with the engineering members to calculate the whole value of the association including value-in-kind sponsoring and other assets.
- Communicate with external companies to arrange an audit of ARIS' financial book.

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 and internal auditor 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
- Yearly book closing, approval by two internal auditors selected by the general assembly

#Weekly	Team-needs revision	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 achieved all its financial goals.

These goals include the reimbursement of the EuRoC member commitment fees, a book profit to cover potential VAT expenses, provisions for the coming cycle, and an increase of the emergency funds. In the cycle 2019/20 ARIS conducted two engineering projects in parallel, both cases coming in under budget thanks to the extraordinary effort of the project teams to close additional material sponsoring deals.

2.3.1 Statement of Financial Position

ASSETS <i>1.10.2019-1.10.2020</i>	CHF
Bank account CHF	79,360.54
Cash on hand CHF	125
Cash on hand USD	364.06
Credit Card Top-Up	57.97
Total Assets	79,907.57
Emergency Provisions	10,000.00

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

The profit gained over the past year covers the expenses associated with the EuRoC 2020 participation and initial spending of project PICCARD.

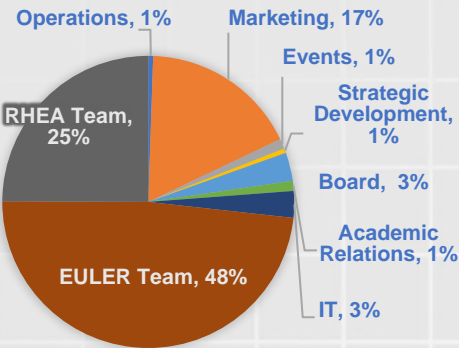
REVENUES	CHF
Membership & commitment fees	4'800.00
Cash sponsoring	79'000.00
Merchandising	2'151.00
Other revenue	3'266.16
Total Revenue	89'217.16
EXPENSES	
Operations	218.89
Marketing	7'184.30
Events	457.6
Strategic Development	204.15
Board	1'297.65
Academic Relations	456.84
IT	1'219.85
EULER Team	19'942.13
RHEA Team	10'286.66
IRIDE Team**	377
Total Expenses	41'645.07
PROFIT/LOSS *	47'572.09

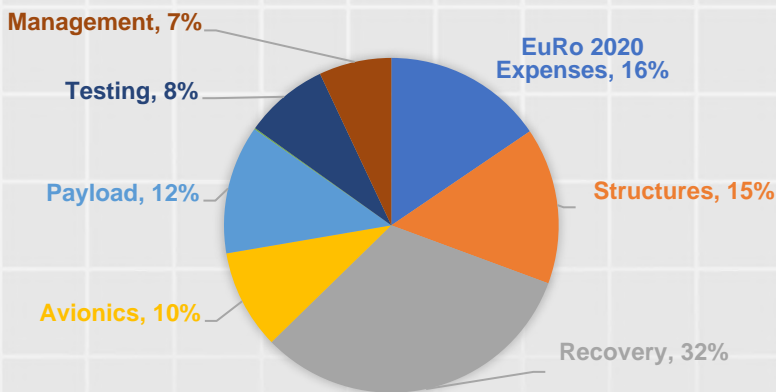
**for the period of 1.10.1019 - 1.10.2020*

***ETH focus projects act financially independent.*

2.3.3 Financial Breakdown

75% of total ARIS cash is associated with engineering project teams, RHEA and EULER. CHF 11'417 (25 %) are required to run the association and covers the expenses of marketing, IT and other teams. Due to COVID-19, most of the ARIS events were transferred to online, being the main reason for 15-times decreased events expenses with respect to the 2018/2019.





Current cash expenses of project EULER amount to CHF 19'942, whereof CHF 18'544.86 (93%) were spend on activities related to developing and contracting the rocket, while other 7% contributes to the management expenses.

2.4 Outlook

2.4.1 Key Learnings

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

- The reimbursement process has been standardized for all the teams and team members by the introduction of a Microsoft Form connected to the new platform Sharepoint.
- All the receipts and invoices are now safely sorted and stored in Sharepoint and can be reached from our accounting software.
- Written procedures for reimbursements, issues or special cases will surely help to smooth further the refund process.
- Automatization and standardization of procedure is key to reduce mistakes and waste less time.

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 2019/2020 financial year ARIS has succeed to double the provisions to CHF 10'000. The goal for the 2020/2021 financial cycle is to further increase it to CHF 20'000.



2.4.3 Budgeting and Tracking

The budget for the 2020/2021 financial cycle has been completed by all teams and discussed in the feedback loop with the Sponsoring team.

TEAMS	TOTAL COSTS, CHF	VALUE IN KIND
Board (<i>Insurance</i>)	10'000	-
Operations	300	-
Marketing	10'000	-
Strategic Development	2'000	-
Academic Projects	10'500	15 %
IT	2'000	-
PICCARD	210'000	32 %
DAEDALUS*	102'000	70 %
PHOENIX*	32'000	60 %
Tripoli Certification	1'200	-
EULER (EuRoC 2020)	20'000	-
Expected Total (CHF)	400'000	160'000

*ETH focus projects act financially independent.

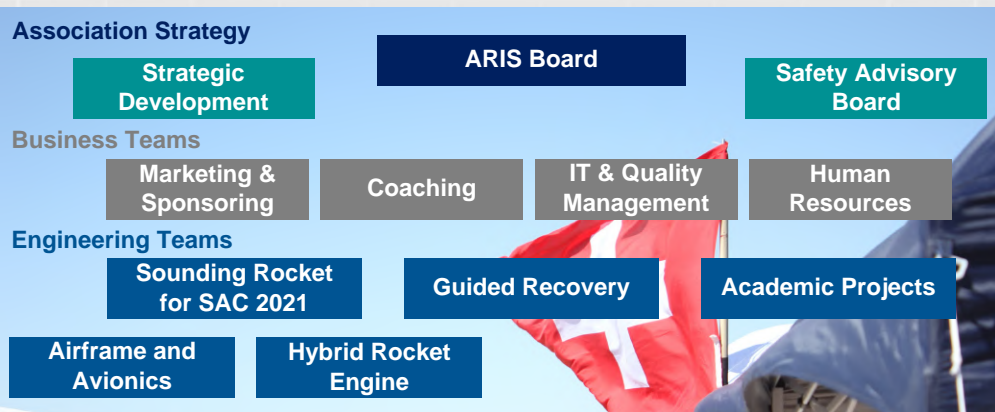


3. ARIS Organizational Changes



Focusing efforts and broadening the horizon:

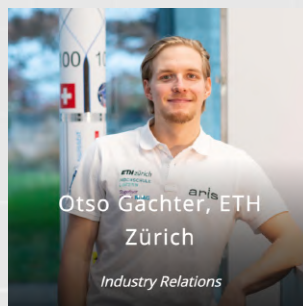
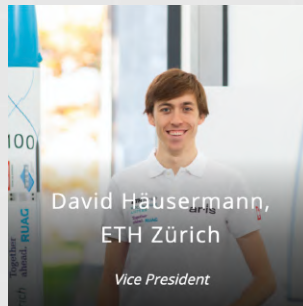
- The **vision and strategy** have been revised: As ARIS we want to *“Contribute to the Advancement of Life and Take Part in Exploring its Origins by Developing Systems Meant for Space”*. Therefore we will keep focusing on the sounding rocket development further developing the airframe, the HRE and the autonomous landing system. Furthermore we plan to launch projects beyond the scope of launch vehicles in September 2021.
- We are honoured to announce that our **partner network in academia and industry** continues to grow. We are especially grateful for many long-term collaborations that have formed over the past years.
- With now three engineering and two strategic projects up and running we count more than **150 active members** in our association.
- In 2019/20 four projects have been concluded: Two HRE development cycles, one sounding rocket project and the ARIS internal IT system have come to a successful end.
- The newly-established **quality control** department is tackling the efficient knowledge transfer process. This year's first technical reviews already showed significant improvement of streamlining the starting phase of new projects.
- A clear distribution of responsibilities within the ARIS association board has led to the organized formation of an **interconnected business team** taking over the resorts of Human Resources, Marketing and Sponsoring, IT Development and Strategic Development.
- Furthermore, a **Safety Advisory Board (SAB)** has been established. Its main task is to ensure safety in all ARIS processes and streamline safety-related efforts within the teams. The SAB will steadily grow into an independent entity of ARIS.



3.1 ARIS Association Board 2019/20

ARIS is a non-profit association and a board is legally required. It consists of six members which are overseeing all association activities by leading the association executively and strategically. Since September 2019, several alterations took place at an Exceptional General Assembly on February 26th, 2020:

- Oliver Kirchhoff, Founder of ARIS and President, left the board and Manuel Gerold, Vice President, was elected as new President.
- David Häusermann, TELL structures member and IRIDE coach, was elected as new Vice President.
- Amir Mikail, Founding Member of ARIS and in charge of Legal / Admin, left the board and Marco Trentini, TELL avionics member and IRIDE coach, was elected for Legal / Admin.
- Giacomo Melegati, former Financial Manager and Treasurer, left the board and Evgeniya Vorobyeva, former Financial Manager, was elected as new Treasurer.
- Felix Dannert, System Engineer of project HEIDI and in charge of Industry Relations, left the board and Otso Gächter, HEIDI recovery lead, was elected for Industry Relations.



3.2 ARIS Safety Advisory Board, Coaching Team and Leadership Coaching

Safety is the number one priority within ARIS. We therefore created a separate entity, the Safety Advisory Board (SAB), consisting of ARIS alumni and experts from industry and academia. The main objectives are keeping the overview for safe procedures within our projects and streamlining efforts within the association. Leadership workshops in direct combination with our strong coaching team guide the teams toward a successful and enjoyable collaboration focusing on transferring the knowledge of previous years.

3.3 Student Projects in 2020/21

ARIS' long-term goal with sounding rockets is to fly and land more accurately. Therefore, in September 2020, we launched three projects building up on knowledge and exploring new technical horizons:

Sounding Rocket Project PICCARD



ARIS' largest, interdisciplinary team consisting of more than 40 students is aiming to push the development of ARIS by competing at the Spaceport America Cup 2021 in the 30k SRAD category building the airframe around DAEDALUS' hybrid-propellant engine and new, active control systems.

Hybrid Rocket Engine Project DAEDALUS



After two successful preceding projects, DAEDALUS will continue the work of projects RHEA and IRIDE by focusing on building a flight-ready hybrid rocket engine. It is the first time a hybrid-propellant rocket engine will be integrated into an ARIS rocket in the association's history.

Guided Recovery Project PHOENIX



Project PHOENIX will set new standards in the field of safe recovery by focusing on guided descents of rockets. The whole project is about implementing a reliable autonomous parachute system to achieve highest precision. Deep understanding in controls and navigation algorithms are crucial for the success of this project.

Strategic Development Team

Within this fiscal year we strive to expand our horizons towards new space-related endeavours. The ARIS strategic development team, a diverse team of ARIS alumni (BSc to PHD students), is elaborating together with experts from academia and industry on the most promising approaches to follow.

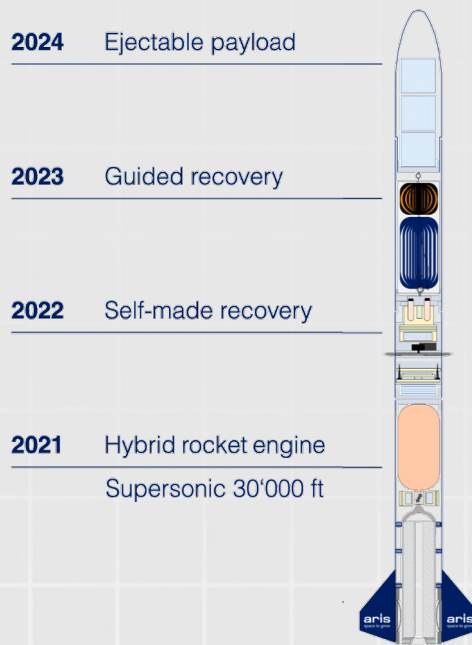
3.4 ARIS Roadmap – Sounding Rocket Development and Beyond

ARIS wants to go high, ARIS wants to set a mark in the exploration of space by realizing sophisticated and meaningful space systems. On the way there, we want to encourage students in taking charge of the future and realizing their visions.

2019/20 can be seen as the next step towards a profound long-term roadmap for ARIS. Based on our revised vision, and the insights gained through our strategic development team, ARIS is aiming to become the centre for space-related research in Switzerland and focusing on developing hardware meant for space.

Currently, the objectives are clear:

- To build a sophisticated, fully student researched and developed sounding rocket flying to altitudes beyond 10 km and featuring an internally developed hybrid rocket engine, a guided recovery system and eventually being able to eject payload at apogee.
- To fly student-built space hardware in orbit by 2029 to mark ARIS' and Switzerland's exploration potential. Whether this system is a rocket, a satellite, rover, ISRU technology demonstrator or any other is currently under investigation with our strategic development team





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space to grow

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