DARE

Delft Aerospace Rocket Engineering

November/December Edition 2018

DARE

Dear reader,

At the beginning of a DARE board year, the Candidate board drafts a policy, giving some general outlines on the course for the year. The main point in our policy is cooperation. Cooperation between teams in DARE and cooperation between DARE and external partners. The former being facilitated by several social events and the weekly DARE wide Wednesday dinner cooked by Stratos IV Management. The latter perfectly picked up during the IAC Bremen where we presented two papers and came in contact with many potential partners in the aerospace industry.

In this policy, also this newsletter was suggested. We are very happy to, so soon already, see our vision for the society taking shape. We are excited for the future of DARE and are looking forward to the great achievements our teams are striving for this year!

As the Christmas holidays approach we wish you all an enjoyable time, best wishes and a happy new year.

Yours sincerely, on behalf of
the Society of DARE,
Rolf Wubben
President of the 18th Board of DARE

Installment 18th DARE Board

DARE is not only a rocket science society

On the 27th of September the 18th Board of Delft Aerospace Rocket Engineering was installed. The board is constituted of Rolf Wubben as President, Jack Kyle as Secretary, Olivier Kuijpers as Treasurer, Daniel Schwering as Commissioner of Internal Affairs and Fabio Kerstens as Commissioner of External Relations. We look forward to building upon the work done by the 17th board and all those before them, to help guide the society towards a successful and productive year!

One of the goals the Board decided on in its policy is the growth of DARE as a society. DARE is more than only engineering and rocket science; it is also a place where friendships for life are forged. Therefore, we aim to bring the society together once a month for an event, e.g. a Christmas dinner or going to the 'First Man' movie together. Not only does this enhance the communication between all teams in DARE but also the productivity on the long run.

Spaceflight is a "hot topic" at this moment, and this also results to DARE growing every year. Besides of educating engineers in the field of rocketry and spaceflight, the Board will also focus on the role of DARE in the (Dutch) society in general, and how it can improve on this in a sustainable way. We find it important to engage with future engineers, and to show our enthusiasm for science and technology to the next generation. Examples of such things already implemented are lecturing primary school children about the basics of rocketry, providing support to high school children with their final high school-research related to rocketry or helping out with the Dutch CanSat launch day. Additionally, we engage in a number of projects with the potential to promote DARE at a European and global level.

DARE has many great projects coming up and we are honored to have received the privilege to help guiding the society for 2018-2019. The Solids Team is making big progress with the Icarus engine for Aether, the Cryogenics Team is close to their first hot fire test and Stratos IV aims for space. Also, research is conducted on staging mechanisms, thrust vector control and more advanced recovery systems. We can't wait to see the boundary breaking innovations become reality!

(From left to right)

Internal Affairs:
Daniel Schwering

Secretary:
Jack Kyle

President:
Rolf Wubben

Treasurer:
Olivier Kuijpers

External Affairs:
Fabio Kerstens

Windtunnel Tests

Recovery is a key aspect of rocketry

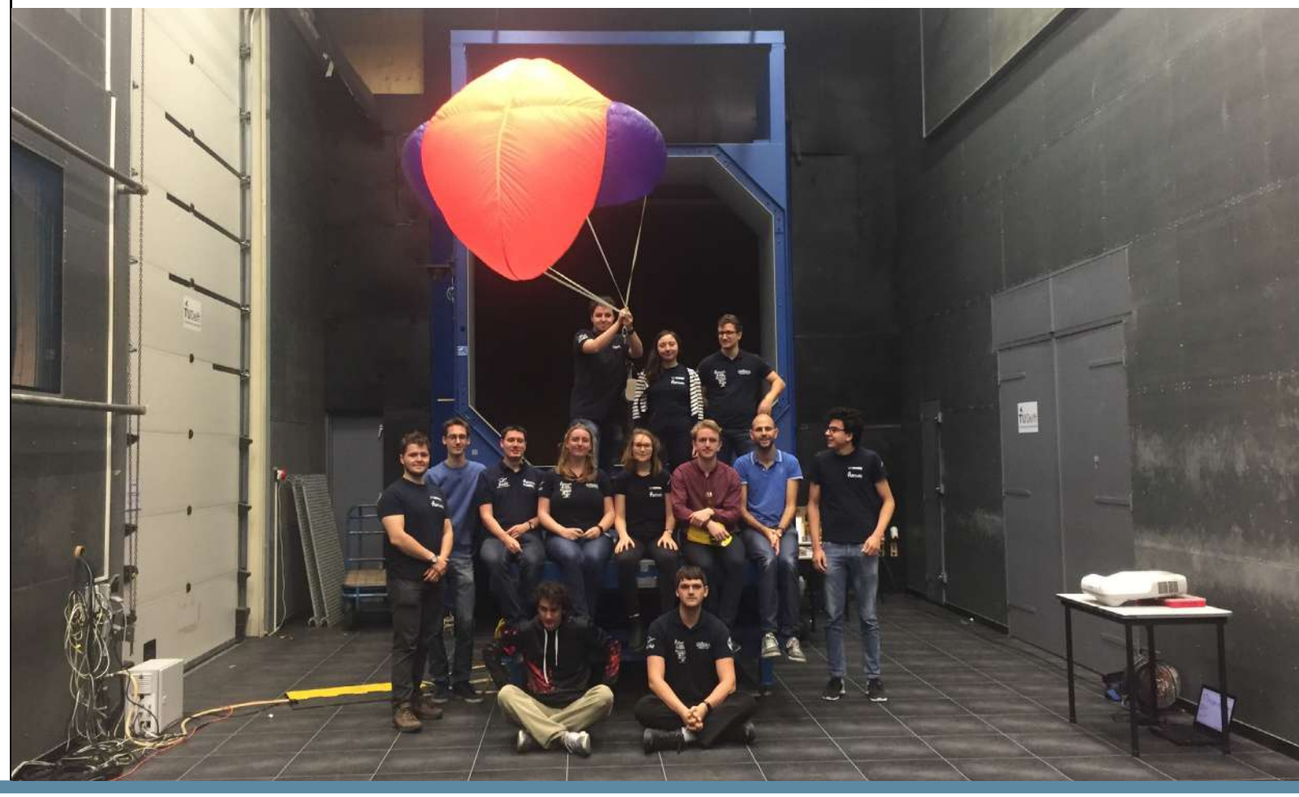
On the 23rd of October, the Parachute Recovery Group (PRG) conducted a series of wind tunnel tests with parachutes in the low-speed wind tunnel at the open jet facility (OJF). The tests conducted were on various parachutes considered for the Stratos project as well as other experimental parachutes that could be used on future missions.

The primary objective of the tests consisted of re-testing and validation of previous assumptions made for the recovery system of Stratos III, as well as reaffirming the data for the use on Stratos IV. This is to make sure that the previous assumptions and designs choices based thereupon are valid for the current project.

Additionally, the new disc-gap-band (DGB) parachute was tested for future consideration. The DGB parachute looks promising and PRG is optimistic about its potential uses aboard future vehicles as a replacement for the current cross parachutes. The DGB has about the same performance in terms of drag coefficient but has a much higher stability. Furthermore, the DGB is capable of reaching supersonic velocities which might be required in a non-nominal recovery situation.

Some difficulty has been encountered during the tests with the parachute bags. This caused the parachutes to either not inflate or inflate much too rapidly. These problems have been traced to a manufacturing error and will be fixed in the upcoming bags.

The conducted tests are extremely useful for both the flagship project Stratos IV, as well as the other DARE projects, continuing our endeavour in reaching, and returning from, space this year. Not only were the current designs put to the tests, but also progress was made on the new designs. The year already looks promising and PRG is looking forward to more progress.



DARE Launch Days

A Windy October day

Rocket science is unprognosable, even more so when it involves a student team with limited resources. The October launch day, unfortunately, became yet another reminder of this mildly infuriating truth.

The launch day was supposed to be a very busy event. At ASK t' Harde, our test location in the Netherlands, we were about to witness three engine tests, as well as the launch of Stratos III±, a smaller version of Stratos III, designed to test the electronics bay of Stratos IV in flight. Moreover, a team of high school students from the Netherlands was supposed to fly their own rocket under DARE's supervision. The keyword here is *was,* as the deteriorated weather conditions of heavy winds resulted in an unsafe situation to launch rockets. Therefore, all launches were cancelled and postponed to our next launch day.

Even with these unfortunate launch circumstances, the team had plenty of work to do, as static engine tests on the ground were possible. The preparation of the test benches and propellant for the engine tests proved to be time consuming, but went without any problems and the engine tests were ready within the time limit. In total, three engine tests were done — two tests of a single grain Icarus engine and one of a newly developed BMX solid engine. The Icarus tests were successful (read more about it in the article on the right), whilst the BMX indicated structural problems resulting in a failed test.

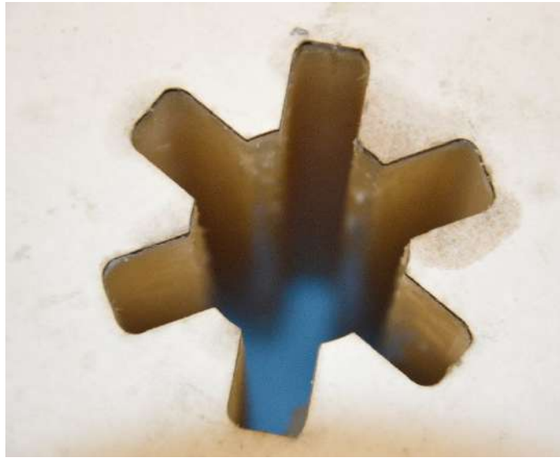
Altogether, despite the limitations set by the weather, the launch day was a success (even though no rockets were launched). The team gathered valuable information about the engines developed, whilst the team of high school students, had a chance to take a glimpse into the research done within DARE; hopefully inspiring them for a future in science or engineering!

The Development of the Icarus Engine and Project Aether

On the October DARE test day, the solid propulsion team had the first successful tests of the DXS (DARE eXperimental Solid) Icarus engine development. The DXS Icarus engine was designed for implementation in Project Aether, one of DARE's flagship projects.

Aether is one of our research vehicles, designed to reach supersonic speeds whilst only flying to low altitudes. This makes it more suitable for a launch from closer European launch sites, simplifying the logistics significantly. The project was originally halted due to issues with the previous engine, the DXS Asimov. However, over the last year the Solid Propulsion Team has worked to develop the new engine, Icarus, which is a vast improvement on its predecessor.

Icarus is also developed using KNSB ("Rocket Candy") as a propellant, which uses sorbitol as a fuel and potassium nitrate as an oxidizer. However, the quality of the propellant has been vastly improved through the application of a vacuum just prior to casting, and by compressing the propellant during curing. This allowed us to obtain densities of 95% of the theoretical value, which is important for improving the reliability and predictability of the engine behaviour. Unlike the Asimov, the Icarus engine utilises a star shaped core, to provide the high initial thrust required to carry Aether out of the tower.



It will also have a stronger, carbon fibre casing, a simpler nozzle design, and it uses snaprings to replace the radial bolts previously used to secure the bulkheads.

An Icarus engine is composed of 7 grains, each with propellant mass of 5.7 kg. Two of these single grains were tested in October at our test facility in the Netherlands, with two different nozzle designs. The first motor reached an operating pressure of about 20 bar whilst the second averaged at 45 bar. Tests at different pressure were performed in order to properly verify the reliability of the simulation tool written by the team over a range of pressures.

Over the next few months, a series of further single grain tests will be performed, which will focus on improving the reliability of engine, ensuring it is operating at the design pressure, and verifying the design of the carbon fibre casing. After these, several full-scale motor tests will occur throughout next year to qualify Icarus for flight.

These first successful engine tests for the Icarus hopefully indicate the relaunch of the Aether project over the next few months, which, under new management, is intended to have its maiden flight during the academic year of 2019-2020.

The People of DARE: Eoghan Gilleran

Team Manager Stratos IV

Eoghan Gilleran
Team Manager Stratos IV

In this article we focus on the people in DARE, this time Eoghan Gilleran, the team manager of Stratos IV project! Before becoming the team manager of Stratos, Eoghan participated in our Small Rocket Project, the Cryogenic Propulsion Team, Thrust Vector Control and the 17th Board of DARE as Treasurer. Read more about his thoughts about the project in this interview!

What is the current state of Stratos IV?

Stratos IV just came out of the preliminary design phase, we have finished the preliminary design review and have now started the detailed design phase. This means we have moved into finalizing the exact dimensions of every single part in the full vehicle.

What were the harsh trade-offs you had to make for Stratos III/IV? Did you have to sacrifice some of the things you really wanted to integrate in the rockets to make it fly?

Currently for Stratos IV, one of the biggest decisions that we had to make is how we wanted to fix the problems we saw in Stratos III. We cannot say what exactly caused the problem yet however we know that the roll frequency of the vehicle played a part in it. We had to choose how to solve that problem and the two main ways of solving that was either actively, through an active roll control system, or passively by tilting the fins. Today in fact, we made the decision, through a trade-off, to go for an active roll control system, so Stratos IV will fly small nitrous oxide monopropellant rocket engines onboard to actively control the rate that we are rolling at, so that was definitely one of our biggest decision so far.

And the launch site for the Stratos IV, is it confirmed yet?

It is not confirmed yet. We are still in discussion with around 4-5 different launch sites, talking about what time of the year works best for them and what sort of safety zone they have in place. Because for a rocket, the higher it goes, the bigger the safety zone that is needed to ensure a safe landing. It's a lengthy process exchanging information of our simulation versus their simulations, so we are still going back and forth with the launch sites, therefore it is hard to say.

When people hear about DARE, one of the first things they hear about Stratos is that the goal is to reach space What happens if Stratos IV reaches space, what comes next?

That is a good question, I think we are far more than just a group of students aiming for space. DARE also allows people to investigate different rocket technologies, which is a nice opportunity to present to people, but it is even better to also then unify these different research efforts towards a single goal which serves as a nice finish line. I think it's not unrealistic in the long term to look towards an orbital launcher. Not in five years, but in ten years it wouldn't be impossible to see students launching an orbital vehicle. DARE is already looking into liquid engines, thrust vector control and control algorithms, so I wouldn't be surprised to see an orbital rocket in DARE's future.

There are many student teams currently aiming for space. Which team would you consider the main competition for DARE, and do you think we are able to reach to space as the first team in the world?

I think DARE is for sure in the running to be the first team to reach space. USCRPL in the United States is definitely one of the big contenders. We saw them with their recent launch attempt to space and we are not so sure when they will launch again. Also, HyEnd in Germany came close to the Karman line (100 km) in the past. One of the biggest uncertainty factors is that we don't know when people will launch, as some teams announce the launch very close to the date. I know there are teams in Boston and other teams in California that can also launch at the notice of only a month. I think there are a lot more contenders joining the race, but I am pretty sure DARE is going to win.

There is one question that is unavoidable, as Stratos III disintegrated, what was the aftermath, how did it affect the team morale?

It's hard to say the anomaly did not affect anyone. Stratos III took two years of work, with many people taking time out from their studies. And then of course four weeks in Spain, where every hour awake was put into preparation, the final integration and the rehearsals. This way everyone got really hyped up for the moment of truth, so it was quite crushing to see two years of work, evaporate in front of their eyes. However, we knew and saw the potential the design had, so I think it's quite rewarding and promising to see that we are building upon their two years of work

Regarding this the in-flight anomaly of Stratos III, is there any progress?

So once everyone returned to Delft from the Stratos III launch campaign, an investigation team was founded, consisting of members of the Stratos III team, who knew the system really well, and members of the Stratos IV team, with no preconception of the anomaly cause, as well as members of DARE's safety board. This team used the telemetry received from the vehicle during flight, as well as the radar and Doppler data measured from the ground, to piece together a picture of what happened to Stratos III. The investigation report is now nearly ready to release, we are just finalising all of the details with the different parties involved, and then we hope to fully disclose the root cause of the Stratos III disintegration.

As Stratos IV is essentially a Stratos III+, what is the biggest challenge for Stratos IV design right now?

While Stratos IV will be an iteration of many of the technologies used in Stratos III, it is very much a new rocket. I think one of the biggest challenges was solving the anomaly we saw with Stratos III, so the implementation of roll control as a part of this solution will be a hugely innovative, new system for us. In the rest of the vehicle we are making many improvements, such as the implementation of the titanium nozzle, composite combustion chamber and a complete redesign of the engine bay (area between the tank and the engine). The oxidizer tank will stay largely the same, but then the nose cone has a lot of changes being made as well, as the recovery system is changed from a cold gas to a hot gas deployment, as well as the addition of a number of new payloads. This way we are putting our own stamp on the rocket, which makes Stratos IV unique. And then the roll control indeed is a completely new system, so the hardware, the thrusters, the control algorithm, the interfacing to the rest of the vehicle, it is all completely new, and something that we must design, build and test within this year, and that's quite a big challenge to face. All of these modifications will ensure we successfully launch an even more innovative, boundary breaking rocket to space in the summer of next year.

Stratos IV PDR

Allowing Stratos IV to go higher than ever before

Every project requires a certain planning to be successful. Stratos is not an exception. The team has set different milestones through the year to ensure that the Stratos IV team reaches their goal of launching the first student rocket to space in the summer of 2019. These milestones consists for example of the preliminary and critical design review, as well as the design freeze at the beginning of 2019.

The preliminary design review (PDR) of the Stratos IV project was held on the 25th of October. On this day, every department presented the conclusions of the initial phase of the design to most of the alumni from previous Stratos projects, as well as to their team members. In the phase leading up to the PDR, the team had been working hard to work out multiple concepts that were selected in the concept design phase. The purpose of the PDR was to get at much feedback as possible, to allow the team to move quickly into the detailed design phase.

While Stratos IV is based on its predecessor, Stratos III, some very important conceptual changes were discussed at the PDR. Some examples are:

- For the nosecone, the shell and tip material will be changed, and more payloads will be housed in it.
- In the recovery bay, the main parachute will be changed from a cross to a disk-gap-band parachute type and the drogue parachute deployment is changed to an pyrotechnic device.
- The upper skirt section, located directly above the tank, will now house the roll control module needed to control the roll rate of the rocket. This is needed because the Stratos III rocket became unstable after 20 seconds of flight, resulting in a rapid unscheduled disassembly. Tiny rocket engines will be put in this section to prevent the rocket from rolling excessively.
- The engine bay section will be completely redesigned to allow for minimum mass, but maintaining maximum accessibility and the required stiffness. A shell concept is chosen here over the skeletal structure, which was chosen for Stratos III.
- The DHX-400 engine will mainly see mass optimization of its very bulky structure. For example, a 3D-printed titanium nozzle will be implemented, as well as a composite combustion chamber. These two changes alone will save approximately 15 kilograms of mass, allowing Stratos IV to go higher than ever before!

IAC Bremen

One of the most exciting weeks of the year

In the first week of October, DARE attended the International Astronomical Conference (IAC) in Bremen for the first time. Upon invitation of ArianeGroup, the Stratos IV management traveled to Bremen to promote DARE and present the latest news on project Stratos.

We had a small display on the ArianeGroup stand, where we presented a number of items. Of particular interest was the 3d-printed titanium nozzle, which is to be implemented in the Stratos IV rocket and will be tested for the first time during an engine test scheduled later this year. It fits right in with the additive manufacturing trend that was visible at this year's IAC.

The conference also provided a great opportunity for the new Stratos team to meet many of the companies and people that have supported the project for years. Moreover, it allowed us to explore a lot of new possibilities and partnerships. This made the week of IAC already one of the best and most exciting week of the year. The enthusiasm that we received from everybody we discussed the project with, was incredibly inspiring. Some of the leading figures in Europe's space industry complemented DARE and the Stratos team on their ambition and level of innovation. This enthusiasm resulted in the team leaving IAC every day with more excitement and inspiration for the project and a stronger believe in realizing our dream of launching a rocket into space.

Besides all this enthusiasm, the Stratos management team has learned that conferences require a tremendous amount of energy, especially when bundled with having to manage a 70 person team from a hotel room in the middle of night.
All in all, IAC has given us a great week and a very exciting start to the project. We believe valuable new partnerships will grow from the foundations that have been created during the conference and we are thankful for everyone's support and enthusiasm. We would like to thank AriangeGroup again for giving us the opportunity attend and display at such a special conference.

Engine Test for Stratos IV

A rewarding experience for the Stratos IV Propulsion Team members

On Wednesday November 28th, the Stratos IV Propulsion Team performed a 22 second static fire of the DHX-400 Nimbus engine, with a peak thrust of 25 kN. It was the first engine test for Stratos IV and for some of the team members their first engine test ever, making this day a very exciting one for the team!

The goal of the first test was to validate the production capabilities of the Stratos IV Propulsion Team, provide data on the performance of the engine and simultaneously teach the new team how to construct and test a rocket engine.

The current configuration of the DHX-400 Nimbus engine was designed entirely by members of Stratos III over the past 2 years. The engine is a hybrid engine composed of a solid fuel grain and Nitrous Oxide as an oxidizer. The majority of the engine was produced in-house with a selection of components produced by external partners.

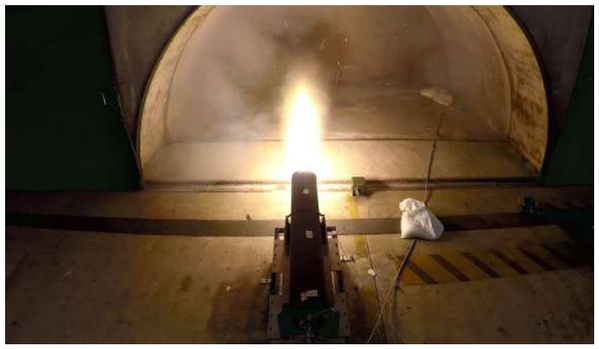
The team spent the last 3 months casting fuel, machining various components and also assembling the full engine. On the test day itself, the team present was divided in different roles to ensure a safe and well-organised test. The primary roles were as follows:

- Test Operator (TO), responsible for handling the system on the test day. Fulfilled by Stratos IV Chief Propulsion Zoë Dickert.
- Test Conductor (TC), responsible for reading the procedures to the Test Operator. Fulfilled by Stratos IV Full Time Engineer Rolf Wubben.
- Control Post (CP), responsible for controlling the valves and sensors on the test stand. Fulfilled by Stratos IV Fulll Time Engineer Arthur Thiam.
- Operation Safety Officier (OSO), responsible for monitoring the safety of the test. Fulfilled by Co-Founder and COO of Dawn Aerospace Tobias Knop, who was also Chief Propulsion Engineer of Stratos II+.

These roles were supported by Stratos IV Chief Engineer Krijn de Kievit, Stratos IV Process Manager Daan van Heeteren, Dion van Stryndonck, Adriaan Smit, Ernst Olberts and Jur Mijjer.

As mentioned before, the test showed a peak thrust of 25 kN. At 22 seconds the engine experienced a burn-through, necessitating a cut-off of the main valve. While the engine did not achieve a full duration burn, it was still a monumental success for the new Stratos IV Propulsion team. It was a rewarding experience for the team members, who worked extremely hard prior to the test. Additionally, the test provided enough validation for the team to move on to their next test.

The coming period, the team will be busy building the next engine. For this engine, a Titanium nozzle will be implemented. This test will be the culmination of years of design work and will be a major innovation in student rocketry! Naturally, we will keep you updated with our ground-breaking and also exciting journey in the next newsletter and on our social media. So stay tuned!



We hope you have enjoyed reading about our journey!

Until the next newsletter, you can stay up-to-date by checking out our social media below:

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