"How do you design something that you do not want to fail while accepting it eventually will?"

At TU Delft we offer you a leading academic programme in aerospace engineering and technology in Europe. Our internationally oriented programme prepares you to respond effectively and rapidly to the needs in the aerospace sector with solutions that are innovative, technically feasible and commercially viable. At our state-of-the-art test and laboratory facilities you acquire the engineering skills needed in advanced industrial applications. During your specialisation phase – the MSc track – you will develop into an independently-thinking, professionally-oriented, innovative engineer and researcher.

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core courses</td>
<td>Gain a broad view on a field of expertise</td>
<td>≥18</td>
</tr>
<tr>
<td>Profile courses</td>
<td>Focus on a particular subfield</td>
<td>≥13</td>
</tr>
<tr>
<td>Elective courses</td>
<td>Specialise in a particular area of expertise or add multidisciplinary elements, repair educational deficiencies or address a personal interest *</td>
<td>+/-16</td>
</tr>
<tr>
<td>Literature study</td>
<td>Prepare for the thesis subject</td>
<td>12</td>
</tr>
<tr>
<td>Research methodologies</td>
<td>Prepare for the thesis subject</td>
<td>2</td>
</tr>
<tr>
<td>Internship</td>
<td>Acquire professional skills during a three-month internship at a Dutch or international company or institute *</td>
<td>18</td>
</tr>
<tr>
<td>MSc thesis</td>
<td>An in-depth research project or design assignment in your subject of choice</td>
<td>42</td>
</tr>
</tbody>
</table>

*Optionally abroad
ASM MSc track

No structure is indestructible. Time, environment, repeated use, and misuse all take their toll on everyday structures, taking advantage of their inherent weaknesses and bringing them closer to failure. This is not the most comforting thought when walking onto an airplane, or driving over a bridge, but it is a reality that structural designers must face; how do you design something that you don’t want to fail while accepting that it eventually will? The answer is: very carefully. The challenges structural engineers are faced with are as follows.

First, they must understand the raw materials and the level of engineering already applied in their creation. Second, they need to synthesize material behaviour and required structural function into a working design. Third, compromises in the working design need to be made to address manufacturability. Finally, all of this must be completed while continually assessing the impact of usage on the durability and longevity of the final structure. The Aerospace Structures and Materials (ASM) MSc track aims to equip students with the necessary knowledge and practical skills necessary to tackle this challenge in an industrial or research environment. From an educational standpoint, students will be exposed to a broad range of courses examining this entire process in the context of the design, manufacturing, and analysis of a composite aircraft wing. This will provide the foundation for subsequent specialization in one of four thematic profiles.

Profiles

Students can graduate within one of the four thematic profiles

1. **Material Analysis** – for students planning to develop materials from micro to macro level and design state-of-the-art solutions in terms of durability of materials as well as their self-healing capacity

2. **Structural Analysis** – students who plan to become structural designers or stress engineers learn to accurately calculate and predict the occurring stresses in structures and come up with clever structural solutions through advanced design techniques and optimization

3. **Manufacturing** – students who aim to become a design-for-manufacturing engineer or work in production surroundings and integrate the needs of the design to production and vice versa

4. **Durability of Structures & Materials** – for students who aim to work for air- and spacecraft manufacturers, and regulators and design for and monitor the structural health of structures & materials or work as certification engineers or crash investigator

Each thematic profile is closely related to the research themes within the department and is supervised by experts in their field. You can select the theme of their choice during the first period of your MSc programme.

Thesis projects can be carried out with any of the research groups within the ASM department, regardless of the thematic profile selected by the student. Additionally, numerous opportunities exist to carry out research within industry under the close supervision of an ASM staff member. After completing the MSc track Aerospace Structures & Materials you will be able to:

- develop design requirements for materials and structures
- design a lightweight structure and explain the reasoning and the physics behind the design
- design a material suitable for aerospace application and explain the reasoning and the physics behind the design
- analyze a structural design using Finite Element Methods

- explain the manufacturing processes and their applications
- select suitable manufacturing processes
- manufacture a prototype
- explain and predict how a design will perform over its life-time and explain how the performance can be monitored

The ASM Track is committed to making the MSc experience a memorable one. In addition to offering a world-class education many opportunities exist for students to expand their horizons through industry involvement, visits and guest lectures. Our students have organized themselves into their own ASM student society, “Enlightness” which organizes lunch lectures, company visits, drinks and the annual ASM career event.

**Academic Staff**

**Professor R. Benedictus** Expertise: Structural Integrity, Metals, Composites, Smart Manufacturing + Automation, Joining Methods, NDT, SHM, Fatigue, Damage Tolerance and Certification

**Professor C. Bisagni** Expertise: Aerospace Structures, Computational Mechanics, Composites, Buckling & Collapse, Multi-scale & Multiphysics, Isogeometric Modeling, Aeroelastic Tailoring, Damage Tolerance & Certification

**Professor W.A. Groen** Expertise: smart materials, piezoelectrics, sensors and energy harvesting materials

**Professor S. van der Zwaag** Expertise: Materials by design, Self-Healing Materials, Metals, Polymers, Sensorial composites

Dr.ir. J.M.J.F. van Campen
Dr.ir. G.N Saunders-Smits
Master Track Coordinators

Sidney graduated from the ASM MSc track in 2014 after doing his thesis at KLM under the supervision of Dr. Irene Fernandez-Villegas and is currently working as a consultant at Berenschot.

“I chose the ASM MSc track as I wanted to do a master track which had a close connection with research and (production) companies to develop materials, processes and designs. My internship at Fokker Aerostructures and my thesis project KLM Engineering & Maintenance were the best experiences during my Masters.

Currently I am an operations consultant implementing and analyzing organizational change projects in the maintenance, repair and overhaul and manufacturing industry.

If you are interested in working together with companies and have interest in applying your research to new products, designs and processes directly, the ASM track is the track to choose.”

Sydney Stokkers (2014)
Research Programmes
The department is home to three strong research groups leading in their field of expertise. Each group collaborates with research partners all over the world, including Airbus, Boeing, NASA, ESA and Embraer:

Novel Aerospace Materials
NovAM is dedicated to the development of novel aerospace and space materials. The Group, consisting of international staff and students, is one of the world’s leading centres of expertise on thermodynamic design of novel alloys, development of novel high performance polymers for structural applications, self-healing materials, functional coatings and smart materials. In their research the group explores unconventional approaches, focus on fundamental concepts but also develops successful concepts to a level suitable for adoption by industry. Example MSc Thesis projects:

- Towards Skin Friction Reduction by Materials Design: Embedded Compliant Linear Structures
- First Steps towards Plasma-Sprayed Liquid Crystal Thermoset: Coatings for Aerospace Applications
- Plasticity Induced Transformation in a New Generation of Titanium Aerospace Alloys

Aerospace Structures & Computational Mechanics
The ASCM group focuses on research in analysis, design, and optimization of advanced structural systems, and the development of necessary computational methods and tools for such activities. Multi-disciplinary projects incorporating aerodynamics, active control, hot structures and actual production tooling are done in cooperation with other sections, aerospace companies and research institutes. The research group enjoys a world-class reputation in these areas. Examples of MSc thesis projects:

- Analysis, Optimum Design, Costeffective Manufacturing and Testing of Advanced Composite Grid-Stiffened Structures for Aircraft Fuselage Applications
- Analytical Stress Field and Failure Prediction of Mechanically Fastened Composites
- An Advanced Aerelastic Tailoring Tool for Wing Design

As a consultant I make little use of my knowledge as an Aerospace Engineer. What I do use is the analytical skills that I developed in Delft. As a consultant you need to grasp a lot of information in short notice, structure problems in an insightful and clear way and develop solutions or approaches to bring a company forward. Typical projects have a duration of 3 months, which means that deadlines are short, but also that you have the opportunity to see many different industries and functions. I really enjoy working in a small team of super smart people (similar to my year in the VSV board or the DSE project). Projects typically have significant impact to the company, which means that we often work with top management. As an Associate I take ownership of a workstream and thus am responsible for that part of the project. I run analyses, have interviews and discussions with clients, have calls with global McKinsey experts, have brainstorm sessions with my team and create documents to present our findings. It is intense, but super interesting work.

My advice is to explore all options intensively, which means talking to staff, fellow students and past students, such that you get a clear view what to expect from each MSc track. In parallel to this “research” you should think what is important to you and what you want to learn now, as well what you like to do in the future. By mapping your needs to the identified options, you can make a trade-off and decision. If you are not sure, just talk to more people.

Arjan Keizer (2011)

After graduating in 2011, Arjan joined McKinsey & Company in Amsterdam as a strategy consultant. From September 2013 until October 2015 he temporarily left McKinsey to develop himself externally: first he worked as Project Manager for Schiphol Airport, followed by a one year MBA at INSEAD, in Singapore and Fontainebleau. In October 2015 he rejoined McKinsey as an Associate.

“I became interested in the ASM track during my DSE Exercise with René Alderliesten, where our team worked on a life extension program for the C130 Hercules. I subsequently decided for ASM, because I was attracted by the interesting opportunities to work with the key Aerospace manufacturers, both as internship opportunity as well as for the thesis work. I did my internship at the Manufacturing Engineering department of Airbus in Stade, where all CFRP parts are manufactured. Another reason to choose ASM was the opportunity for my thesis work to combine modeling, designing, building and testing.

I really enjoyed the last six months of my thesis work. I worked on the design of a lower wing panel made from Fiber Metal Laminates (GLARE). After an intensive literature study, I set-up a test program to analyze the impact of different adhesively bonded doubler run-out designs. I measured the delamination growth rate at different fatigue load levels as well as the bending by using DIC (digital image correlation). I compared these results with Finite Element analyses and empirical formulas. Producing my own specimen, fatigue testing the parts and analyzing the results was very interesting and a lot of fun. The good atmosphere with my fellow graduate and PhD students further strengthened the good experience.

The Group, consisting of international staff and students, is one of the world’s leading centres of expertise on thermodynamic design of novel alloys, development of novel high performance polymers for structural applications, self-healing materials, functional coatings and smart materials. In their research the group explores unconventional approaches, focus on fundamental concepts but also develops successful concepts to a level suitable for adoption by industry. Example MSc Thesis projects:
Structural Integrity and Composites
The SI&C group closes the loop from design to realization by focusing on research related to the manufacturing, maintaining, and repairing aerospace structures. Aerospace structures will degrade over time and eventually fail as a result of regular use (fatigue), corrosion, wear, ageing, and accidental damage over their lifetimes. Furthermore, these processes are intimately linked to the starting conditions of the structure such as: manufacturing and variations in individual aircraft usage. This defines the three research pillars of the group:

- Fatigue, Damage Tolerance, and Durability
- Manufacturing; and Nondestructive Testing
- Structural and Health Monitoring

The aim of the research is to increase our knowledge within and bridging between these three pillars for metal, composite, and hybrid aerospace structures. This will equip the next generation of structural designers with the knowledge and knowhow to optimize aerospace structures safely to their limit. Examples of MSc Thesis projects:

- Development of a Damage Tolerance Evaluation procedure for bonded composite repairs
- Selective Reinforcements for improving Damage Tolerance of Stringerless Fuselages
- Aircraft Fuselage Design Study
- Applicability of Magnesium in FML for Aerospace Applications
- Explosive Forming of Sheet Metal

Aerospace Structures
The department has its own laboratory: the Delft Aerospace Structures and Materials Laboratory, where we offer our MSc students working on their thesis projects access to the most advanced facilities. The laboratory contains a wide range of specialist equipment with uses including:

- material characterization using visual methods like microscopes, physical methods, chemical analysis, nondestructive testing methods, etc.
- synthesis of materials, both on microlevel in our chemical laboratory and on macro-level in the composite laboratory
- manufacturing processes for the fabrication of parts and products. Examples include high presses, resin injection techniques, filament winding, forming processes, processes for joining of structural elements, etc.
- testing of materials and structures for which a wide range of testing equipment is available
- in the workshop, a number of numerically-controlled milling machines are used for the manufacture of any specimens, tools, dies or other test equipment that may be required.

Job Prospects
Graduates from the ASM track are in high demand. Many find jobs even before they graduate and go on to work both within the field of Aerospace and further afield. Many go on to work at Airbus, Fokker, Eurocopter and their many suppliers and contractors, but also in the automotive industry at Mercedes, BMW and McLaren. Other students start their own companies or work in other fields such as consultancy and finance. Finally, Aerospace Structures, some pursue a PhD degree either at TU Delft or further afield.

Admission requirements:
- a Dutch BSc degree in Aerospace Engineering, Mechanical Engineering, Maritime Engineering, Electrical Engineering, Civil Engineering, Physics, Applied Physics, or Physics & Astronomy or
- A BSc degree in Military Systems & Technology of the Netherlands Defense Academy (NLDA) or
- a Dutch degree of a University of Applied Sciences in Aeronautics, Aviation, Mechanical Engineering, Maritime Engineering, Civil Engineering, Design & Innovation. These students have to complete a special bridging programme prior to enrolment on the MSc.

Details about the admission with a BSc degree from a non-Dutch university are available on the TU Delft website: www.tudelft.nl/admission

Permission for doing research within this track of this Master is partly dependent on a screening under the Missile and Nuclear Research Exemption scheme: https://www.government.nl/topics/secondary-vocational-education-mbo-and-higher-education/exemption-certain-engineering-or-nuclear-related-courses-of-study

For further information
More information on the MSc track in Aerospace Structures and Materials can be obtained at:
www.lr.tudelft.nl/asm

Alternatively, please contact the MSc Track Coordinators:
Dr.ir.Julien van Campen
T +31 15 27 85321
Dr.ir. G.N Saunders-Smits
T +31 15 28 85369
E MScCoordinator-ASM@tudelft.nl

International students are recommended to visit:
www.tudelft.nl/admission

www.facebook.com/TUDelftAerospaceEngineering
@AETUDelft
instagram.com/TUDelft
www.campus.tudelft.nl

September 2017