The Control & Operations core course programme provides a fundamental background in operations research, avionics systems, flight control and automation. The profile courses a student attends are associated with one of three sections (research groups) the student has joined. The 3 to 4 additional elective courses are chosen after consulting with the responsible Section head. After completing the required course programme and the internship, the student performs the literature survey associated with his or her thesis. The literature survey and final thesis project are performed with the same supervisor, working on a specific project of current relevance to the field.
Profiles
Profile I: Control & Simulation (C&S)
The Control & Simulation section strives to improve the safety of aerospace operations through the design and experimental evaluation of automatic flight control systems, human-machine systems, sense & avoid and air traffic management systems. By modelling the dynamic behaviour of flying vehicles, C&S explores the entire scope of control options, ranging from manual towards full autonomous control.

The section has three knowledge clusters that each focus on a distinct element of modern aerospace systems. It houses the Micro-Air Vehicle laboratory, MAV-lab, which studies Unmanned Aerial Vehicles (UAVs), the research flight simulator SIMONA and the CESSNA CITATION laboratory aircraft. In these laboratories many of the theoretical innovations are experimentally tested in real or simulated flight.

Aerospace Guidance, Control and Navigation focuses on the development of new generations of flight control systems, with superior performance and the ability to compensate automatically for technical faults. Topics include:
- Nonlinear dynamics, optimization and control
- Adaptive and reconfigurable flight control
- Helicopter flight dynamics and handling qualities
- State estimation and distributed control
- Vision-based autonomous operations

Aerospace Human-Machine Systems aims at supporting the human operator in manual and supervisory control tasks, through developing innovative human-machine interfaces and clever automation tools. Topics include:
- Cybernetic pilot perception and control models
- Haptic control systems, bio-dynamics
- Flight simulators and pilot training
- Ecological interfaces and cognitive systems
- Cockpit and air traffic control interfaces

Communication, Navigation & Surveillance in Air Traffic Management studies the sensors and systems enabling flight operations and Air Traffic Management (ATM), through simulating air traffic and designing novel equipment and algorithms. Topics include:
- Autonomous operations with Airborne Separation Assistance Systems
- Sense and avoid systems in the cockpit, on the ground and for UAVs
- Data-mining and big data applications, e.g., ADS-B
- Complexity of traffic patterns and traffic flows
- Scientific foundations of air traffic management and trajectory planning

Profile II Aircraft Noise and Climate Effects (ANCE)
The section Aircraft Noise and Climate Effects (ANCE) studies the environmental impact of aviation through developing accurate models for the prediction of aircraft noise, emissions and climate effects. Aircraft noise continues to be a very serious source of disturbance to the public. Current contribution of aircraft emissions to global warming is estimated to lie in between 1.5 and 5.5%, but is predicted to increase significantly. In addition, the level of scientific understanding of the climate effects of aviation is low. The vision of ANCE is that for the growth of aviation (5 % per year) to be sustainable with a decreasing impact on the environment, more accurate modelling of the impact due to noise and emissions is required. ANCE has two knowledge clusters:

Aircraft Noise
For aircraft noise, the modelling chain comprises the acoustic source, that is the aircraft, via the propagation medium, that is the atmosphere, to the final noise impact as perceived on the ground. Research topics include:
- Weather-dependent noise contour modelling, fully accounting for the temperature and wind speed gradients in the atmosphere
- Detailed aircraft noise source modelling, both considering the engines and airframe, also for the assessment of new aircraft technologies
- Acoustic camera imaging for noise source identification on aircraft and in more fundamental aero-acoustic research in wind tunnels
- Auralization (aural simulation) of aircraft noise and assessment in perception based metrics applied to both current aircraft as well as to the design of new aircraft and flight procedures
- The aircraft noise research is carried out in close cooperation with NLR, DLR, Empa and Airbus.

Testimonial Profile I - Control and Simulation
Looking back, my decision to study the MSc profile Control and Simulation at TU Delft was definitely the right choice. The highly-qualified scientific and teaching staff are well-known in their respective fields, but at the same time are easily approachable.

During the thesis, students are given excellent guidance from expert supervisors and are also given the freedom to use the numerous facilities available, which includes two flight simulators and a laboratory aircraft (amongst others). I feel confident that the MSc programme at Control and Simulation has provided me with the necessary skills needed to pursue a successful professional career in the future.

Emmanuel Sunil, MSc (2014)
Studies of the effects of aircraft emissions on climate change

Here the approach is to use models capable of assessing the aviation induced climate effects by calculating the contribution of the individual climate agents (CO2, NOx, contrails, O3). This enables the assessment of the effectiveness of mitigation measures such as changing flight settings or supersonic flying. This research is executed in close cooperation with DLR.

Profile III Air Transport Operations (ATO)
The Section Air Transport and Operations (ATO) studies the efficiency, safety and resilience of aerospace operations through mathematical models and simulations that analyse, explain, predict and optimise the performance of air transport operations.

The suitable ATO student profile:
- solid mathematical background
- good programming skills
- fundamental understanding of flight performance
- interest in modelling operational processes and dynamics
- ability to work independently
- critical attitude

AIRLINE OPERATIONS:
This theme addresses the operational and maintenance expertise together. Operational fields of interest include the optimisation of networks, fleet configuration, scheduling and daily disruptions. Maintenance includes RAMS (Reliability, Availability, Maintainability, Supportability) expertise in general and sub themes such as: reliability modelling, maintenance planning optimisation and knowledge-based maintenance tools development.

FLIGHT OPERATIONS:
This theme focuses on the efficient ground and airborne operations of aircraft. Techniques such as linear programming and aircraft trajectory optimisation are used to model and optimise the (cost) efficiency and safety of ground and flight operations. Main themes include airport ground movements, airport capacity, innovative aircraft operations and environmental impact of aircraft operations.

Testimonial Profile II - Aircraft Noise and Climate Effects

My thesis research about aircraft noise during the final approach phase covered many disciplines. I applied new theories to analyse noise and executed noise measurements at Schiphol Airport. The section provided good guidance and offered a lot of personal attention. Still there is plenty of room for own ideas and to take on opportunities to work with external parties such as the NLR. Also many aerospace disciples come together in the ANCE research field, which really fascinates me. Overall I’m glad that I choose this section to perform my graduation research.

Testimonial Profile III - Air Transport Operations

One of the reasons I chose to study here is because of the international student mix, connections to worldwide experts, and a wide array of opportunities. I am an Indian, but I’ve lived the majority of my life in foreign countries, and I feel perfectly comfortable in this faculty. While studying ATO, I took opportunities that I never would have or even thought of taking. For instance, I was the first TU Delft student to do an internship in Albania for an airline called Belle Air. It ended up being one of the most exciting parts of extending my studies in ATO into the real world, putting my engineering education to the test.

Testimonial Profile II - Aircraft Noise and Climate Effects (ANCE)

My thesis research is on algorithm-based climate cost functions (CCFs) for the new European Horizon 2020 program ATM4E, in cooperation with DLR and University of Reading. A high-fidelity global climate model will be used to analyse the impact of aviation emissions in a 4D grid for specific weather patterns. These are then input to an Air Traffic Management (ATM) simulation to optimise air traffic for climate impact based on that day’s weather. Previous results show a potential of 25% decrease in climate impact for only a 0.5% cost increase! The combination of both noise and climate within ANCE makes for an interesting, multidisciplinary environment and the amount of cooperation with NLR and DLR means there’s a lot of opportunities outside Delft.
AIR TRAFFIC MANAGEMENT SAFETY: This theme focuses on safety and resilience implications of a future design in air traffic operations. The applications range from commercial to unmanned flights. If a design aims to improve capacity, economy or efficiency, safety and resilience implications should be understood as well. Systematic analysis is conducted primarily by means of agent-based modelling and (rare event) Monte Carlo simulation. The key objective is providing effective feedback to the design.

**Academic Staff**
- Professor J.M. (Jacco) Hoekstra Control and Simulation (C&S)
- Professor M. (Max) Mulder Control and Simulation (C&S)
- Professor D.G. (Dick) Simons Aircraft Noise, Emissions and Climate Effects (ANCE)
- Professor H.A.P. (Henk) Blom Air Transport & Operations (ATO)
- Professor R. (Ricky) Curran Air Transport & Operations (ATO)
- Dr (Clark) Borst, Track coordinator Control and Simulation (C&S)
- Professor V. (Volker) Grewe (ANCE)

**Job perspectives**
The job perspectives for C&O students continue to be extremely bright, and many students have several job offers before they graduate. The versatile character of the MSC track leads to high-quality graduates with a great variety of where they start their societal career. Examples are large multinational industries (Boeing, Airbus/ EADS, Eurocopter, BMW, Mercedes, Shell, ASML, AirFrance/KLM), established research laboratories (NLR, DLR, Eurocontrol, Max Planck, NASA), and consultancy and finance (McKinsey, Bain, BCG, ING, Deutsche Bank).

A considerable number of students go and work directly in air transport, entering air traffic control, or even become pilots. Finally, a significant number of our students enter academic life and become a PhD student at high-ranking universities.

**Research programmes and internships**
The research programmes are identical to the three profiles summarized above, for more information contact the professors or consult the three Section’s web sites. Most of the C&O students do their internships abroad at major international companies (e.g., BMW, Boeing, Airbus, Nissan) or research laboratories (NASA, Max Planck, DLR). About half of the C&O internships are organized by the section at which the student has enrolled, using the personal network of the responsible professors. The internship is not necessarily aligned to the C&O knowledge base. On the contrary, students are free to search for an internship themselves, using their own network or with help from the Faculty’s internship coordinator. Internships can be done on all subjects of interest, as long as they have an academic component.

**Admission requirements:**
- A BSc degree in Military Systems & Technology of the Netherlands Defense Academy (NLDA) involving Aerospace related subjects
- A BSc degree in Military Platform Systems of the Netherlands Defence Academy (NLDA) with a profile strongly related to aircraft design or aircraft operations can be admitted to the programme. To obtain admission to the programme, please send a mail (with documents) to the Director of Education (HYPERLINK "mailto:Education-AE@tudelft.nl" Education-AE@tudelft.nl) 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: www.government.nl/topics/secondary-vocational-education-mbo-and-higher-education/exemption-certain-engineering-or-nuclear-related-courses-of-study

More information on the MSc track “Control & Operations” can be obtained at: www.ir.tudelft.nl/co

Alternatively, you can also contact the MSc track coordinator:
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E c.borst@tudelft.nl
T +31 15 27 89099
Room number: 0.26

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

For further information