Droplet Impact on Gaps and Sharp Edges

In this work we aim to analyse the secondary droplets generated by the impact of a single drop on a dry surface with different gaps and edges configurations. Using a shadowgraph technique, the student has to investigate the formed crown and the secondary droplets with statistical methods. For this propose a flywheel experiment has been developed at the Multiphase Flow and Icing department of the Institute of Fluid Mechanics. In order to detect all the small droplets, the experiments have to be performed using high resolution CCD cameras, a long distance microscope and PIV lasers with diffusor optics.

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Fig. 1: Corona and secondary droplets formed after the impact of a droplet on a thin gap
Experiments in flow control with circulation control wings

The collaborative research center 880 (SFB880, https://www.tu-braunschweig.de/sfb880) develops the fundamentals of active high-lift for environmentally friendly future transport aircraft. The performance of aircraft with short take-off and landing capabilities can be improved by using circulation control wings with active blowing. Economic efficiency of commercial aircraft calls for maximizing the ratio of lift gain over blowing momentum. The project therefore investigates the efficiency of active blowing using an experimental approach. Further efficiency improvements are targeted through dynamic segmented spanwise blowing as well as closed-loop flow control attained by machine learning. As a participant of this research project, you will assist in preparing and carrying out measurements in wind and/or water tunnel facilities as well as post processing of experimental data.

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Figure 1: Laser visualization of the flow in the wake of a Coanda flap.
Parameterisation of Turboprop S-Duct Intake for Aerodynamic Design by CFD Analysis

A regional passenger aircraft with high-lift capability is the design objective of the SFB880 project, in which IFAS has the research focus on the integration of the engine and the design of its intake. The intake becomes a critical component of the integration due to the high power demand considering the active high-lift and the high subsonic cruise mission. The focus of this work is on the parametric analysis of the turboprop S-duct intake to define its aerodynamic design space. The project starts with the parameterization of the basis intake model by its cross-sections. An interface program in Matlab will be written to convert the parametric model to the numerical simulation model. Verification will be done using CFD methods on 2D meridional plane in comparison to turboprop S-ducts from literature (Little, 1982). In the second phase, the model will be simulated using 3D RANS, which will serve as the initial estimation for the S-duct design.

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Figure 2: (left) Wrap-around S-duct intake from Little, 1982; (right) wrap- around S-duct model for simulation grid generation
Simulation of Thermal Barrier Coatings in Rocket Engines

The gas temperature inside a rocket engine can reach values of more than 3000°C. To protect the rocket chamber from the resulting thermal load, it is cooled from the inside using liquid hydrogen and made of copper alloys that have a high thermal conductivity. Although the surface temperature of the copper liner can be reduced to temperatures of about 700°C, failure may still occur. In this project, thermal barrier coatings are developed that can reduce the temperature of the copper alloy and thus improve its temperature resistance. The effects of these coating systems are studied using finite element simulations.

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Fig. 1: Finite element simulation of a thermal barrier coating system in a rocket engine.
Improvement of the Oxidation Resistance of Titanium Alloys

Even if Titanium alloys show outstanding specific fatigue properties, their application in aircraft engines is limited due to their poor oxidation resistance. Above 550°C the protective TiO₂ oxide layer becomes permeable for Oxygen leading to severe oxidation at the oxide-metal-interface. The addition of Niobium and Silicon to Titanium alloys leads to reduced oxidation whereas the underlying mechanisms are not yet well understood.

In the current work, different binary and ternary Titanium alloys will be produced and analysed with respect to their oxidation resistance by means of optical microscopy, scanning electron microscopy and micro-focused hard X-ray phase analyses, see figure 1.

Please note that for reasons of work security, knowledge of the German language is required for experimental work.

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Fig. 1: Micro-focused hard X-ray experiment carried out at the synchrotron PETRA III of HASYLAB, DESY. Different zones are detected by phase analyses at Ti 2Nb alloy after oxidation at 800°C for 96 hours.
Collision avoidance in long-term simulations of the space debris environment

One of the research areas of the Institute of Space Systems is the modelling and simulation of the space debris environment. Based on models the current state, simulations of its long-term evolution are performed. During these simulations, all major sinks and sources for space debris are considered. One major source of new debris objects are collision fragments, whereas the underlying collision rates are calculated using different statistical algorithms. One important measure to avoid collisions is collision avoidance of operational spacecraft. To this point, collision avoidance has only simulated by setting the collision rates of operational spacecraft to zero. While this assumption is reasonable to assess the potential benefit of perfect collision avoidance, is neglects the fact that not all collisions can be avoided. Furthermore, this approach delivers no further information on operational details such as the fuel consumption for collision avoidance or the needed maneuver frequency. To close this gap, the collision rate algorithms shall be extended by a suitable method to estimate maneuver frequency and fuel consumption for collision avoidance.

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Dimensional analysis for CubeSat design and dynamics mapping

Experimental validation is the final step in the development of systems and algorithms in aerospace engineering. To fulfil its purpose, the experimental environment and the test object should replicate the real world as faithful as possible. That means ideally that the test mockup should be exactly the same system supposed to fly and the experimental environment exactly the same mission environment. This is often not the case, meaning that experimental validation does not include the validation of flight hardware/software but is only limited to method-validation.

IRAS is building an air-bearing testbed to validate flight hardware/software. Therefore it’s necessary to replicate real subsystems on the test mockup and real orbital mechanics on experimental environment. In this work the powerful technique of dimensional analysis should be analyzed and assessed in its suitability to perform the following tasks:

- **Test mockup design:** Satellite subsystem design by means of the Buckingham-Pi-Theorem. The idea is to identify relevant ratios and non-dimensional parameters and “quickly” design a new CubeSat based on former designs. The SQL-Based CubeSat Analyse and Design Tool (QuSAD) contains an SQL database with available commercial off the shelf (COTS) CubeSat components, which will be used in this study.

- **Experimental environment:** The experimental reproducing of orbital mechanics in an air-bearing test environment. That means that the dynamics of motion, especially formation flight (Clohessy Wiltshire equations), and atmospheric perturbations has to be mapped into a planar 7m x 4m motion. The problem of accurate actuation should be investigated.

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Low-Level jet (LLJ) in coastal environt

- Familiarisation with the topic low-level jet (LLJ) in coastal environment.
- Analyses of wind lidar data (Weibull distribution), measured for one year at North Sea island of Helgoland, revision of existing matlab routines for data evaluation.
- Discussion and interpretation of wind data concerning the frequency of occurrence, intensity, properties and typical life cycle (diurnal, seasonal) of LLJ.
- Analyses of land/onshore circulation.
- Documentation of the work in the form of a bachelor thesis

Recommended References:


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Algorithms and Processing of GNSS Measurements for Precise Point Positioning (PPP)

Positioning with Global Navigation Satellite Systems (GNSS) has been used on various applications for years. The achievable accuracy for the usual standalone positioning depends on multiple parameters, but usually is in the range of a few meters. With the availability of more GNSS constellations and civil usable signals on different frequencies, the positioning performance will even improve in the future.

For applications demanding for higher precision, an approach called Precise Point Positioning (PPP) has been developed. This technique uses additional data as well as models of different GNSS errors in order to calculate a precise position solution based on GNSS measurements. The additional data includes precise orbit information as well as parameters for the error models and is usually produced by global networks of receivers like the International GNSS Service (IGS). However, as this data is usually not available in real-time, PPP is mainly used for post-processing of recorded GNSS data. PPP is implemented in different usable software solutions, but is also available as web services. PPP can provide world-wide highly accurate positioning for stationary and moving users.

The first step of this task is to familiarize with the ideas, algorithms and tools used for PPP. In a second step, different PPP solutions can be compared by processing identical input data. For this, GNSS data recorded by a stationary reference receiver at the institute of flight guidance can be used.

![Different GNSS Satellites](image)

**Figure 3: Different GNSS Satellites**

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Experiments and Simulation of a Low Frequency De-icing System based on harmonic excitation

The Low Frequency De-icing system is a mechanical system based on structural vibrations of the unstiffened sections. Due to a suitable actuator and its position the skin is excited at its natural frequency. The applied actuators are piezoelectric patch actuators based on the \( d_{31} \)-effect, which are placed at the inner side of the leading edge. This excitation allows large deformations with a small energy input, since the actuator only has to overcome the structural damping. In addition to the experiments a finite element model was developed to identify suitable actuator positions and eigenmodes of the test specimen. For a better understanding of the de-icing mechanism and to improve the finite element model further studies are necessary.

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Figure 4: Before and after De-icing of a NACA0012-Profil, tested in an icing wind tunnel
Modelling Microcracking in a Composite Laminate

There are several models of microcracking in special laminates like cross-plies available in literature. Codes for their use are only partly open for use. It is the aim of this project to extend an existing tool to more interesting laminate types. This has to be validated by literature results.

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Fig. 1: Typical laminate (non-crimp fabric) with microcracking