

Andrew Hartman

Host Institute: Institute of Aerodynamics & Gas Dynamics

Host University: University of Stuttgart

University of Arizona

Major: Mechanical Engineering

Project Name: Film Cooling in Supersonic Flows

I have been given a great deal of advice over the course of my life regarding what to spend my time and money doing, most of which was to choose experiences over things. To see new things, meet new people, and do things that make you feel uncomfortable, instead of simply staying in one place and buying things that you think will make you happy. Despite this, for most of my life I have looked to things for happiness. I bought a cool car and spent all of my free time and money making it faster and making it look better. All the while living on the farm where I was born and raised, and going to a University that was just 50 miles away. That was until this past year when I decided to leave that behind and pursue a completely different experience. I applied for the SUPER program and was given the opportunity to spend a summer in Stuttgart while I performed research at the University of Stuttgart on Film Cooling in Supersonic flows. The time that I spent in Germany while participating in the program was, without a doubt, the greatest experience of my life.

When I first arrived in Germany I was greeted by my distant cousins whom my grandmother had kept in touch with over the years. I stayed with my family members in the town of Heilbronn, 50 kilometers south of Stuttgart, for a few days before the SUPER program officially began. This was my first time abroad and I found that although I was excited to begin this new experience, I was at the same time a little bit nervous and uncomfortable being in a completely different country. I noticed that I was hesitant to speak English in public because I didn't want people to find out that I was a foreigner. However, this changed very soon once I realized how friendly nearly everyone was and that people were not only able but happy to speak English. Once I arrived in Stuttgart, my buddy for the SUPER program, Savio, was very helpful in explaining how to live in the city. He explained how the U-bahn and S-bahn systems worked, how stores close earlier than in the US and are not even open on Sundays, and showed me some of the best parts of the city. Within the first few days I was able to make friends with the other SUPER participants and I already knew that my time in Germany was going to be a life changing experience.



*A view of Neuschwanstein in the bottom left with the city of Füssen in the background*

As I prepared to begin working at my host institute, the IAG, I expected the atmosphere there to be very formal. I expected there to be a rigid start and end time for the day and that everyone in the institute would be wearing formal attire. This was because I had always been told that Germans were very formal and punctual people. As a result, nearly all of the clothes that I brought to Germany were formal. Upon arriving at my host institute and meeting my supervising PHd student, Johannes, I was surprised to see that he and everyone else in the institute were wearing shorts and t-shirts. I was even more surprised, albeit very pleasantly, when he told me that I could get to the institute at whatever time worked best for me and leave when I wanted. The atmosphere at my institute was much more relaxed than I had anticipated. If you work more effectively in the morning you could show up as early as you want and if the afternoon was your most productive time you could get there later and stay later. A much higher precedence was placed upon conducting your research effectively and making notable progress, instead of on arbitrary rules such as a dress code and fixed working hours, and I really liked this mindset. Once I began my actual research at the institute I found the material to be fascinating. The project that I worked on involved investigating the effectiveness of injecting a cooling gas along the wall of a rocket nozzle with supersonic flow. My role in the project was to run numerical simulations for this flow where I would vary certain parameters such as the composition of the cooling gas that was injected, the speed at which the gas was injected, the Mach number of the bulk flow through the nozzle and several other parameters. I would then take the raw data from these simulations and then use a Tecplot 360, a postprocessing program, in order to analyze the data and plot the heat flux along the nozzle wall for each of the configurations. I could then compare the plots for each configuration and determine which parameters provided the greatest decrease in heat flux and which configuration was ideal for the operation of the nozzle. While working on this project many valuable new skills such as how to navigate through a Linux operating system, how to use numerical simulations to model a flow and how to perform research at a University level. I was also able to make friends with a few to the other masters and bachelors student in the institute and had a great time going to a few of the on-campus parties that the University hosted. I really enjoyed the overall feel of the University.



Over the course of the summer I truly enjoyed living in the city of Stuttgart. As I stated earlier, I grew up on a farm in the United States and had never lived in a large city before. Surprisingly, living in Stuttgart didn't feel overwhelming and by the end of my two month stay there I was pretty comfortable walking around the city and felt at home. In America, I am very used to getting in my car and driving if I want to go to the store or run an errand. In fact, on the very rare occasions that I do decide to walk somewhere people will usually stop and ask if I need help, because it is so unusual to see a person walking, especially during the Summer in Arizona. However, in Stuttgart I was able to walk to the store, or if it was a longer distance, use the U-bahn or S-bahn system with ease. Although I had a few issues with the transit systems at first, such as getting on the wrong S-bahn a few times, I found that in most cases it was far less stressful and faster to take the public transit than it was to drive through the city. One of my favorite things about Stuttgart was the rich history and culture of the city. Instead of a typical dense urban landscape, there were vineyards near the center of the city, large cathedrals across the city, and my favorite parts of the city, Schlossplatz, which was a beautiful area with a large open area with the new and old castles of Stuttgart next to each other. Another one of my favorite parts of the city was the Mittlerer Schlossgarten, or State Park, that was across the street from my apartment. It was very relaxing to walk through the park on the weekends and I had some great times at the beer garden in the park.

The highlights of the summer were when I would travel outside of Stuttgart, on days off and weekends, with the other SUPER students. Some of the places inside Germany that I traveled to were Munich, the Black Forest, Tubingen, Heidelberg, Berlin, Hamburg, Cologne, and my favorite the Nürburgring to watch an endurance race. I also had the opportunity to spend five days in Greece on the island of Santorini with a few of the other students. This was a completely unexpected trip but when a few of the other students invited me to go along with them I did, and it was a great experience. The fact the Germany is centrally located in Europe meant that it wasn't very difficult or expensive to travel to the best places in Europe. Coming from the United States it would cost over \$2,000 to travel to Greece in airfare alone, but from Germany it was only a 300-euro flight round trip. At the end of the summer my little brother flew out to Germany and we rented a car and drove through Austria, the Czech Republic, and then back into Germany through Berlin, Hamburg, Cologne, and then back to Stuttgart. This was a great experience and gave me the chance to see a lot of the smaller villages and countryside's in Central Europe.



Some advice that I have for future SUPER participants is to be open to try all of the German food you can, buy the monthly transit pass, drive on the autobahn if you get the chance because it is awesome, if you are invited to go somewhere just go, and try to experience as much as you can. Also, when you travel to a new city don't simply go to all of the main attractions and then leave. I found that wandering through a city and exploring new areas gave a better sense of what the city and the people in it were like, instead of just seeing all of the other tourists at the main landmarks. My time in Germany was truly life changing and I already know that this past summer will be a highlight of my life. I would like to thank the Christian Bürkert foundation for supporting the SUPER program and allowing myself and all of the other participants to have such an amazing and lifechanging experience.



I give consent to publish this report on the webpage of the Christian Bürkert stiftung and University of Stuttgart.

Signed: Andrew Hartman