

Lockheed Martin Internship

June 4th, 2024

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Introduction

On January 8th 2024, five Danish engineering students arrived in DFW Airport, marking the beginning of a half-year stay in Fort Worth, Texas. The stay in Fort Worth is part of the international F-35 internship program running between Terma A/S and Lockheed Martin, aiming to enhance international business relations and give the new generation of Danish engineers valuable insights in international relations and differences in work cultures. Through the program we, the engineering students, gain hands-on experience within cutting edge technological fields, apply our knowledge on real products in real production lines and get the chance to develop advanced solutions for the biggest defense program ever. We work across cultures, gain insights in the often unnoticed, intricate differences across western cultures and develop our understanding of work and workplaces.



Figure 1: We, the Danish Fort Worth interns – William, Eline, Aksel, Gustav and Jacob

Apart from the official, work related side of the program, we have been given a unique chance to live in, travel through and explore the United States of America. We have met new people, new cultures, developed friendships and for the half year period truly lived in the US.

Our time here has been packed with impressions, experiences and lessons. Throughout this report I will try to share some of the major aspects – mostly in relation to Lockheed Martin and our efforts in the F-35 JSF program. The main points will be the facility in Fort Worth, two of our projects: the NUNCHUCK system and the FOD eRacer, and experiencing life and travelling in USA.

Fort Worth, Texas

Located in extension of the more well-known Dallas, Fort Worth is a growing city, housing just shy of a million residents. In Fort Worth is located the United States Air Force Plant 4, sharing an airfield with Lockheed Martin Aeronautics. This is where the main production line for the F-35 jets is located and where we worked. The factory itself was built in 1941, as a production site for the B-24 Liberator. Today, the mile long factory floor has been transformed to a hub of cutting edge tools, robotics and data gathering instruments. Structural sections are making their way from one end to the other, taking on panels, electronics, fasteners, hydraulics and other subsections – until a finished F-35 ultimately arrives at the end of the factory. The factory is beyond huge and host to local infrastructure, such as indoor roads, transport cranes, pedestrian walks and different cafes and cafeterias. It is never empty and arriving to work is almost like stepping into a small, indoor city.



Figure 2: View of Airforce Plant 4 from Lake Worth

The scale of production is unlike anything any of us have seen or experienced back in Denmark and it comes with its own set of pros and cons, however, the focus will remain on our work in the plant. Due to problems with security clearance, the five of us ended in OpsTech – a department tasked with developing tools and technology for aiding/supporting the processes on the factory floor. While Eline, William and I remained in OpsTech, Aksel and Jacob switched to the Quality Engineering department, where they had originally intended to work.

Within OpsTech, Eline, William and I were deployed in the FOD AI team – a small group working on implementing Artificial Intelligence as means for detection of Foreign Object Debris.

FOD AI and the NUNCHUCK system

One of the main focus areas of the entire F-35 production line is Foreign Object Debris (FOD). In short, FOD can be classified as anything inside of the plane that is not part of the aircraft. Without constant focus on eliminating FOD, it will naturally occur and build up within the aircraft. Bits of tape, loose washers, metal shavings etc. can sometimes be missed inside of the plane during assembly, mounting and production. It requires constant monitoring, inspections and rigorous clean ups to ensure nothing is left inside the plane when it takes off from the airfield.

Eliminating FOD is not only a matter of delivering a clean product, but a direct safety measure that could mean the difference between life and death upon take-off. During maneuvering, the aircraft is exposed to tremendous acceleration in three dimensions, possibly migrating FOD to anywhere within the jet. It can jam fuel pumps, short electronics, clog fuel lines or knock other parts loose.

One of the measures taken to minimize the presence of FOD, is implementation of an AI system to help mechanics and inspectors identify FOD. This system, adequately named the FOD AI, is composed of a cart and a wand. The cart carries a powerful computer, running the AI inference and displaying the result on an on-board monitor. The wand carries a camera, which delivers the images for the AI to analyze.

From the beginning of our internship, we received feedback from the people on the floor, recognizing the key aspects limiting the FOD AI usability:

1. It is big, heavy and wired.
The powerful computer running the AI is placed within a cart and the video stream is running through a USB connection. This requires the user to drag the cart along with them around the plane, through small openings and up and down elevators. It also leaves a cable between the cart and themselves - for people to potentially trip on.
2. The camera is too big.
Although an upgrade from the previous inspection tools, the camera used on the wand of the FOD AI system is still too big. It cannot get into the tight spaces of the bay, which have to be inspected.
3. It cannot document FOD findings.
Although a camera and live video is already present, the system offers no way of documenting findings. It specifically lacks a capture button on the wand.

Throughout our time at Lockheed Martin, our projects revolved around further developing the FOD AI system. While Eline specifically worked towards improving the training of AI systems like the one present on the FOD AI cart, William and I worked on improving the mentioned issues, reported by the mechanics and inspectors on the floor.

In an attempt to fix size, mobility and reporting for the FOD AI, we launched the NUNCHUCK project. At its core, the NUNCHUCKS were supposed to be a wireless extension of the FOD AI. The wand should be connected to a tablet-like device, which would transmit a live video stream to the cart, while receiving the FOD AI inference results and display them on the tablet. The naming of the system stems from the wand and tablet being tethered together, thus loosely resembling Chinese nunchaku.

While the basic concept seemed simple enough, integration of wireless technology on a factory the size of a small city does come with its challenges. Furthermore, wireless live streaming of highly confidential images of the internal workings of a 5th gen military aircraft comes with even more challenges – and its fair share of skepticism.

While the specific measures taken to meet the requirements set by Wireless Management and Security at Lockheed Martin will remain confidential, we will admit it ended up becoming anything but simple.

The entire NUNCHUCK system had to be custom designed, custom made, programmed with custom firmware and running custom algorithms. While the system did rely on some off-the-shelf parts, every step of the data processing and transmission required some level of specialized solution, in order to meet requirements.

Hardware, firmware and software went through multiple iterations before settling on a functional system. We had to touch upon nearly every area within electrical engineering and spent the vast majority of our time trying to get the system running. As I am writing this report, the NUNCHUCK system works and it is capable of delivering a steady, high definition live stream, without compromising on security or wireless integrity. It establishes a wireless link with the FOD AI cart and allows the operator to search for FOD with the AI acting as a second pair of eyes. Furthermore, the NUNCHUCK system is left open-ended for further development and allows easy integration of other tools on its platform.

One such tool would be the FOD eRacer.

FOD eRacer

In addition to the NUNCHUCK system, a separate project was initiated at the start of our internship – the FOD eRacer. Originally pitched by James “Jimmy” Mullins, the eRacer was meant to be used by mechanics and inspectors on the floor. It was to carry a camera and UV lights on its body and have mounted wheels, so the user could roll it over the skin surface of the aircraft. The tool was meant to deliver clear vision inside of the mounting holes of the aircraft, as tiny pieces of FOD would often be left in the holes. Especially rubber plugs, which would be removed early in the manufacturing process, would leave debris inside of the holes. To make the debris easy to spot, the rubber plugs are made of fluorescent rubber – thus lighting up when exposed to UV.

Prior to the introduction of the FOD eRacer, mechanics and inspectors would search the mounting holes for debris by means of a UV flashlight and careful circular inspection around the sides of the holes. Although effective, the process is slow and tedious, especially due to the flashlight blocking the line of sight of the inspector.

Whereas the NUNCHUCK system was a complex system, seeing constant development throughout the entire internship, the FOD eRacer was a relatively simple system, which led it to be under prioritized by us interns. Our Tech Lead, Alexander Tramm, had originally established the eRacer as a project within our team, after meeting with Jimmy. While we interns admittedly failed to pay attention to the possible value of the eRacer, Alexander insisted on its development.

The responsibility of the eRacer development was placed upon Jacob in the beginning, but as he left OpsTech to work in quality engineering, the project stagnated. It later became Williams responsibility, but ultimately ended up as mine. The design saw a total of six iterations, before a working prototype could be delivered to Jimy for testing. The sixth, seventh and eighth design iterations included multiple additional features, to the ones originally requested by Jimy. These came as a result of the collaborative process between Jimy, Alexander and I, which in just short of a month delivered a version ready for manufacturing.

The parallel development of the NUNCHUCKs and eRacer was the primary driver for changing the NUNCHUCK scope from a stand-alone product to a development platform. This decision turned to our immediate favor, as requests for the presence of AI in hole inspections followed almost every demonstration of the eRacer tool.

FOD eRacer launch

Development was done in close collaboration with Jimy, as he had originally requested the product. Upon receiving the sixth iteration of the eRacer, he deemed the product sufficiently finished for launching and started spreading the word of a new tool. In addition to Jimy's efforts on the floor, Alexander continued to support the project and made the project visible across our team and department. The last iterations of the eRacer saw multiple rounds of feedback from inspectors and mechanics on the floor – almost exclusively positive. Suddenly, finishing the eRacer was a top priority. Whereas formerly under prioritized, the demand for the tool had skyrocketed and in a matter of weeks, numerous teams had requested the tool for use at their stations. At the time of writing this report, our team is considering submitting the FOD eRacer for a patent and actions have already been taken to funnel funding and preparing a pilot for implementation of the eRacer on the floor.

From the perspective of an intern, development and deployment of the eRacer has been an experience beyond anything I would ever dare to expect. Collaborating with colleagues across teams and departments, to design and deliver a product that will see deployment across the factory has been an amazing experience.

As a whole, the work we have done at Lockheed Martin has been challenging, exciting and has reached far beyond the common tasks one would expect to find in an internship position. In addition to the work itself, we have had the privilege of meeting with people from across the different layers found throughout the defense industry. We have attended meetings and met with the Danish Minister of Defense Troels Lund Poulsen, Brigadier General His Royal Highness Prince Joachim of Denmark, Ambassadors of Denmark, representatives of multiple Danish political parties, President of LM Aero Greg Ulmer and various VPs and directors - and we have been working closely with managers and people on the floor.



Figure 3: Left - Troels Lund Poulsen, Danish MOD visit.



Right – Brigadier Gen. HRH Prince Joachim of Denmark visit

The eRacer project and launch has especially led to insights and experiences across organizational layers. The project grabbed the attention of executive leadership and gave me the chance to demo and discuss the tool with vice presidents in both manufacturing and quality. Meetings with higher management, iterative design collaboration with inspectors, attending manufacturing conventions to find manufacturers, securing funding, establishing official documentation, preparing patent submission and going through tool checks within Lockheed Martin has all been valuable experiences that no educational institution could offer.

For navigating through, and including me in the launch of the eRacer, I want to express my gratitude to Alexander Tramm. Thank you for bringing me along.

Experiencing Texas and USA

Outside of our work in Lockheed, we have lived life in Texas and travelled across the states. As the internship has gone on for years, it has attracted amazing people, who has welcomed us interns and offered us amazing and truly Texan experiences, some of which include:

The couple Cami and Andre has taken us two-stepping and line dancing, at Guitars and Cadillacs – a honky tonk (bar) specifically for western dancing.

Another couple, Bradley and Travis, has been our guardian angels and helped us throughout the internship. They made sure we got settled in Texas, they took us out for our first beer, they helped us through a car crash and they even invited us to the Fort Worth ballet, to experience the classic Beauty and the Beast.

Our close team at Lockheed, consisting of Jon Olson, Alexander Tramm, Andrew Rebeck, Jean-Pierre Njock II and David Coleman has taken us out for dinner, drinks, basketball games, baseball, concerts, workouts, parties and axe throwing.

Jimmy, the inspector requesting the eRacer, has invited us out to shoot some of his guns on a gun range and Leon, an inspector manager, has taken us through a skeet shooting course.

The southern hospitality has been a theme of our stay and all the people we have met has been kind and welcoming. Of all our experiences in Texas, my personal favorite was our hunting trip. Roy, who used to share office space with previous inters, had reached out from across the facility to invite us to a weekend trip just south of Houston. Here, in his parents' house, we would be staying with him and his family and hunt hogs on his parents' vast property. As hogs is an invasive species in Texas, anyone is allowed and encouraged to hunt them at any time of the year. After a brief instruction on where to hide and where to hit the animal, we were waiting for a hog to pass by. Previous interns had visited Roys family to hunt, but we were the first to get one – only a couple hours after arriving. It was shot by Jacob, but the second one followed the morning after – and I was lucky enough to shoot it.



Figure 4: Roy helping us haul a hog back to the house after our second hunt

Immediately after shooting the hogs, Roy would help us haul them back and walk us through skinning, gutting and butchering the animal. It was a little tough to stomach at times, but it was a good lesson on where one's food actually comes from and I am very grateful to have tried it. After two hunts, alligator safari, guided tours around the property, lovely meals by Roys Mom, and a trip to the coast for a dip in the Mexican Gulf, we were on our way home with about 20kg of wild pork – all of which we hope to grill for our farewell BBQ party.

Apart from our good times in Texas, we have travelled to New Orleans, Washington DC, New York City and Las Vegas. Out of all our trips, travelling to NYC with Aksel was by far my favorite. It was short, but intense. Early in our internship, an unknown number had texted me, to let me know that they were thinking of me, as they had just visited Amsterdam. Since we inherit earlier interns phone numbers, I assumed it was a friend of an earlier Dutch intern – which turned out to be correct. I let them know that I was a new guy and after a bit of texting back and forth, they turned out to be Christine, a girl living in NYC – she even offered to show Aksel and me around town. The invitation from Christine led to a spontaneous “why not?” theme of the trip to NYC, which turned out to be a blast. We made a ton of new friends, met up with old friends from DTU who live in New York, we went out every night and tried to explore as much of Manhattan as possible during the day. We saw all the iconic buildings like Empire State, Flatiron, Chrysler tower, Grand Central Station, Statue of Liberty, the stock exchange, Brooklyn Bridge and the urban canyons. We went through the city to find the best pizza spots, we went to an intimate jazz concert, we tried different restaurants and street food, we saw the natural museum of history, we enjoyed modern art at MoMA, went for a stroll in central park and so much more.

Although NYC is said to be for rough and reserved people, the hospitality and welcoming we experienced was through the roof and we owe a special thanks to Christine, Drew and Felix for showing us around New York.



Figure 5: Aksel and I by Brooklyn Bridge

Acknowledgements

Our time working for Lockheed and experiencing USA has been amazing, and we owe a special thanks to the people who has welcomed us and made our stay become so much more than an internship.

MSM / OpsTech team

Thank you to our amazing team in MSM/OpsTech in Lockheed Martin, for supporting us through challenging projects and giving us the opportunity to define projects that fit our skillsets. I am grateful for the work environment and the time taken to escort us around the facility, but also for the time we have spent outside of work. I owe a special thanks to Jon Olson, Alexander Tramm and Jean Pierre Njock II. Thank you to Jon Olson and Alexander Tramm for supporting both the eRacer and the NUNCHUCK development, for believing in and committing fully to our ideas, and for letting me take part in every step of the development. In addition to the work itself, I am grateful for the support we have received from Jon Olson and Alexander Tramm, regarding our unfortunate situations with FVRs, vehicles and water damage.

In addition, I owe a special thanks to Alexander Tramm and Jean Pierre Njock II for our time spent outside of work, both in workouts, dinners, drinks and parties.

Travis and Bradley

Although not official affiliated with the Lockheed Martin international internship, Travis and Bradley has taken on an essential role as our guardian angels, for which we are incredibly grateful. We owe a special thanks to Travis and Bradley for greeting us in Texas, helping us settle down, helping us figure out our apartment situation, helping us with cars, helping us with water damage and for being the ones who helped us through a severe car crash. Travis and Bradley deserve all the recognition they can get, as they take on so much responsibility out of pure kindness – thank you!

Terma A/S

For making the internship possible and for letting us get this amazing opportunity, we owe a special thanks to Terma A/S and the people behind the internship. Within Terma, we owe a special thanks to Donny Weaver, for greeting us in the US, acting as our American link to Terma and for taking us out.

Conclusion

At the beginning of 2024, we arrived in Fort Worth and embarked on our adventure working for Lockheed Martin and taking part in the international collaboration present in the F-35 program. Since then we have explored the US, met amazing people, worked across cultures and widened horizons.

We may conclude, that the aim to give the new generation of Danish engineers valuable insights in international relations and differences in work cultures has been met. We have been challenged on our technical capabilities, we have experienced working in an environment vastly different than those present in Denmark and we have taken part in the international relations between Denmark and the US. The experience as a whole has been intense, action packed, eye-opening and well beyond anything I could have hoped for. Although the US and Lockheed has much more to offer, our time here is near its end - and I must admit:

I do look forward to returning home to friends and family.

Thank you to everyone involved in our stay

/Gustav "Goose" Friis Fléron