

Internship at Lockheed Martin Spring 2024

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Figure 1 - Source :<https://www.lockheedmartin.com/en-us/products/f-35.html>

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United States Air Force Plant 4 and Lockheed Martin: A Legacy of Innovation

Nestled within the heart of Fort Worth, lies the United States Air Force Plant 4, a facility with a long history of aerospace excellence. Since its inception, the plant has been synonymous with groundbreaking innovation and the production of some of the world's most iconic military aircraft. At the heart of its legacy stands Lockheed Martin, a titan in the aerospace industry.

Established during World War II, the facility had a pivotal role in supporting the war by producing the B-24 liberator. This plane was an American heavy bomber that was used extensively in strategic bombing operations. Over 3000 planes were manufactured, assembled and modified during the war. In late 2017 the last of 3620 F-16's was rolled out. This plane is a big part of the legacy of this air base. The prototype to the F-16, the YF-16, was manufactured here in 1970, and in 1978 the USAF accepted its first F-16. Since then this plant has produced the majority of the F-16's ever built.

Today only the F-35 is in production at this facility. The F-35 Lightning II is the most advanced multirole stealth fighter ever built. Being witness to this jet in real life, I can confidently say that Lockheed Martin's F-35 can lay ownership of this title. The telling of the Lightning II is a conundrum of how to fit terabytes of sensor data into a single pilot and making this understandable to be able to operate in a high stress environment in the cockpit. This is achieved through advanced computing that compresses the data into a human interpretable form. The pilot's helmet gives the visual feedback from all these sensors and even lets them see underneath the airplane to scan their surroundings. Technology like this truly makes this aircraft a next-generation fighter.

Another contributing factor to the F-35 programs success is the international collaboration. The Danish company TERMA constructs over a hundred different components on the F-35. Among these are parts of the center fuselage and the gun bay, which can hold additional weapons. These are manufactured and shipped from Denmark all the way to the United States. But Denmark is just one among the many suppliers to the program, other supporting countries are Britain, Italy, The Netherlands, Canada, Australia, Denmark and Norway. It is a monumental task to coordinate all of these shipments and thoroughly document each step in each component, to achieve the finalized product being assembled in Fort Worth.

On my first day at Lockheed I was struck with awe by witnessing the intricate process of aircraft assembly. The movie Top Gun starring Tom Cruise has encapsulated the intensity and raw enthusiasm surrounding fighter jets. Since then I have had an interest in fighter jets and hearing a roaring jet engine always introduces goosebumps. Now I could witness how these machines were created myself. Innovation and dedication permeated every aspect of the operations in the mile long production line. From the skilled technicians on the factory floor to the visionary

engineers in the design studios, Lockheed Martin's commitment to excellence was evident at every turn.

Work at Lockheed Martin

My work at Lockheed Martin has primarily been focusing on FOD AI, which is a FOD inspection tool developed by the team at Operations and Technology. FOD stands for foreign object debris or foreign object damage. It is essentially objects left in the F-35 during assembly. All throughout the production the prevention of FOD is crucial to make sure undesired objects does not trickle down into the later stages of assembly. These objects pose a danger to the pilot operating the aircraft and it is therefore the inspectors' job to prevent them getting to the customer. FOD AI uses image recognition on a camera input to discern the foreign objects from the background. This model is run on a powerful PC situated on a cart with a battery. This cart is named the FOD AI cart. Previous year's interns had developed and trained the AI model and created the first iteration of the cart. However there were still some challenges concerning hardware. A long USB cable would run to a handheld camera that provides the camera video input. The captured video plus the output of the AI model would then be displayed on the handheld monitor. Some issues did arise in regards to these cables, since they are carrying high data rates the length of the cables are limited. Therefore new solutions be carried out to combat these difficulties. The conclusion was that a new system should be designed without the use of long cables. This would make for a more mobile and user friendly system for the inspectors.

The Nunchuck

The FOD AI Nunchuck will replace the long cables running to the monitor and handheld camera with a wireless alternative. This will help the inspectors by having a more portable solution. It would also reduce tripping hazards from long cables drawn across the floor. The major challenge of creating a video stream from the Nunchuck to the cart was establishing a video transfer feed. Because of security reasons a software defined radio was chosen for the task. This allows for a custom set of frequencies to be determined by the user. The basic working principle of the SDR is that all the data manipulation and handling is done digitally. This means that the SDR just samples the incoming radio frequencies and performs some rudimentary radio filtering. The result is digital samples of actual radio waves. Then all the signal processing can be done on the CPU. This gives some upsides in the freedom of choice of modulation technique and signal processing, but comes at the cost of CPU power. This was a major restriction on the Nunchuck's requirements. But with this downside accounted for, the SDR allowed for a lot of different design possibilities.

On the Nunchuck, the video stream from the camera was transformed into packet sized chunks and modulated, such that it could be sampled by the SDR and transmit over the air. On the receiving side of the cart, the signal was picked up by another radio. Then signal corrections and demodulation was performed to obtain the original video stream. All of this had to be fast. The

latency had to be reduced to be barely noticeable for the system to be viable. This proved to be extremely difficult.

Since the time of writing, the Nunchuck system is still in development. But being an open platform, new additions and different task can easily be applied if needed.

Data compression

With the video stream established, a method of sending the output of the cart's AI model to the Nunchuck was required. This meant a secondary radio link. Since the data rate for the secondary radio link was limited, a clever way to achieve a better data compression was adopted. This meant that the masks of the AI model could be represented by just a few mathematical coefficients. This allowed for compressed data in the magnitudes of hundreds. So by sending theses coefficients instead of the whole mask, they could be reconstructed on the Nunchuck with great precision. This solution showcases how performance can be greatly increased, by just adding a bit more preprocessing to your data.

Conclusion

By using a radio signal the previously wired camera and monitor could be made wireless. Through custom hardware solutions and integrations the system can be made more mobile and less cumbersome for the inspectors. This will hopefully help increase the accuracy and speed of the inspections, benefitting the F-35 productions line and leading to a higher quality product.

This project was challenging since the documentation is scarce on the internet about software defined radios. Much of the work had to be done as trial and error, and the whole system had to be troubleshoot from top till bottom multiple times. Streaming video in real time was also challenging since the processing power was limited. Moreover the FOD AI also adds a slight delay due to processing leading to even tighter restrictions on the delay. My work at Lockheed Martin has been very challenging and I was able to push my knowledge and abilities to their limit, while having great coworkers who helped me throughout the process.

Experiences in the USA

Outside of work we also went on a lot of travels around Texas but also the larger USA. It was convenient flying interstate to see other parts of the states, and there was ample opportunity for things to see.

New Orleans

New Orleans had a special charm to it. The old buildings from the colonial era was reminiscent of an old European town. The buildings were well kept and gave the streets its soul. In sharp contrast was the other side of the main street with hotels and more modern architecture. In the French District we were greeted by live music performances and people exhibiting their own art. Fortune tellers and people selling pearls and other Mardi Gras themed stuff littered the streets. Seafood and beignets were the best food in the city, and we enjoyed it a lot.

The city at night was totally different compared to the day. On Bourbon streets the bars stretched for almost a mile. Every need in terms of music, atmosphere and beverages could be met, and if you did not like it at one bar the bar next over could suit your needs. Walking away from Bourbon Street led us to Frenchman street. Here the jazz bars were located. Numerous performances were carried out into the night and the rooms were packed by listeners of all ages. With the reputation that New Orleans has for jazz meant that people only brought their best. We also went further outside of the city and into the swamps. Taking a bus took us into the swampland where we got a boat tour. The change of scenery was sorely needed from all the parading and drinking. We saw many alligators, albeit small they were still cool to witness. They did not seem to be bothered by our presence at all.

New Orleans was an amazing experience. The city had music food and partying and did not disappoint in any aspect. Going there by plane is very easy and the city is only 40 minutes from the airport. We slept in New Orleans City House which was a hostel mostly for young people travelling. There were many people from all over the country but also other parts of the world. A great place to meet some fellow Europeans. Outside of Mardi Gras season the city is more chill and the partying at night should be less overwhelming.

Washington DC

We ventured northward and arrived in the capital city of Washington DC, where history comes alive amidst iconic monuments and world-class museums. The Washington memorial park was a wonder to behold. All the cherries were blossoming which attracted huge crowds of people taking pictures. We were lucky that we arrived when we did, for the blossoming lasted only a

short while. But behind all the cherry trees stood all the memorial cites. Some dated back to the emancipation of the US like the big obelisk called the Washington memorial and the Jefferson memorial. Some were related to the people's liberation, such as the Martin Luther King Jr. and the Lincoln memorial. The statue of Lincoln towered above everyone in the room and had a powerful gaze pointed into the horizon. Near a fountain was a WWII memorial commemorating all the states, territories and countries that joined Americans in their war effort. A sign said that the soldiers had bathed in the fountain upon their return from victory.

The Smithsonian museums were a testament to the richness of American history, culture and innovation. They were free to enter and attracted a great many peoples. You could find a museum that suited you, whatever the taste. One of the highlight of my visit was the Smithsonian National Air and Space Museum. Here I marveled at the wonders of flight and space exploration. From the Wright brothers' first powered aircraft to the Discovery space shuttle, each artifact told a story of human ingenuity and daring adventure. Modern jetfighters were also. The jaw dropping SR-71 Blackbird was the first thing that met your eyes when you stepped in. Being one of my favorite planes it was truly a wonder to see it in person. Next was the X-35, the prototype to the F-35, stood on display and was a reminder of how far the evolution of this product had come to be where we are today. The list of amazing aircrafts at this museum goes on and on.

Stepping into the grandeur of the Smithsonian National Museum of Art enveloped me in a world of artistic wonder and cultural treasures. The museum housed some masterpieces of iconic American landscapes. These paintings evoked the spirit of the early settlers their experience encountering this vast unexplored land. From the rugged beauty of the western frontier to the bustling streets of urban America, the collection offered a vivid collection of the nation's artistic heritage. The museum also had some impressive modern paintings. Among the more surreal paintings in the collection were the German expressionists. These paintings captured the raw emotion in people and chills were induced in their presence. This artistic style was shaped by to the horrors of the First World War.

Outside of the museums and the park the city lacked the life and the soul of something like New Orleans. Mostly corporate buildings and hotels filled the streets, and the cold marble exteriors of the parliament and The White House made the city feel very distant and corporate. A well worth visit for some history on the American culture and aeronautics, but if a rich city life is desired, other places might be of more interest.

Austin, Texas

Austin was a different city compared to Fort Worth. The great influx of people from other states, such as California, has created a culture not focused on trucks and cowboys, but more around cozy cafes and creativity. It was a city sprawling with color all throughout its nightlife. Being a college city, many young people filled the bars during Friday and Saturday, and the bars were occupied all the way down the street. It was not just the Texan who lived here but people

from all around the country. It could clearly be seen that this was a town in growth because many high rises were being built.

Besides going to bars at night we also saw some of the town. In contrast to many American cities it is walkable all throughout. Cafes and niche antique stores were to be found all over the place. The Colorado River runs through the city and makes the landscape around lush and crawling with life. Canoes and kayaks can be rented down the river and the water is usually calm and still, giving the opportunity for a nice and comfortable afternoon on the water. The bats under the bridge were also unique to the city. Thousands of bats will leave every night from that bridge.

The comedy club was some of the best laughs we had, and quite affordable too. For only 25\$ a head we got 2 hours of entertainment by five comics. We went to The Creek and Cave, but there are many more clubs like it. Joe Rogan also has his comedy club there called The Mothership. We would have liked to go but could not get any tickets. So if you are planning to go look into getting tickets early!

Austin is one of the best places to go to if you are young and looking to party. It was a very friendly city with great hotels. Definitely worth a weekend trip.

Acknowledgments

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