# Transfer Document Here

This document servers to support the project transfer to the next ADS-Company, working with Here Lidar data. In this document we will briefly touch upon the initial goal in the project and its progression throughout, the taken steps with their respective results, as well as our client interaction and recommendations on continuing the project.

## Goal Of the Project

The initial goal of the project was to use the meta-data of Lidar Images (Shot from lidar cameras) to determine attributes such as car speed, which in turn could lead to the possibility of early detection of potential collisions. Combining this calculation with the image would allow for plotting the car-speed as overlay to the image (speed per recognized car).

As the project developed, our goal changed. Due to the challenge the project posed in the beginning; the goal was altered to using Deep learning to recognize traffic objects through shot images. Later, the image with classified cars would be combined with the Lidar data (depth) to determine the distance of each car in an image in respective to the car carrying the Lidar Cams.

## Intermediate steps & Results

1. Gathering the Data
   1. We initially had trouble gathering the data from the Here company itself. This became a potential threat as we wanted to progress our project but did not have the data. The solution to this was to use the AUDI A2D2 Public data, which according to the Here representatives of Mumbai, matched their format.
   2. A2D2 Dataset: https://www.a2d2.audi/a2d2/en.html
   3. All our results are based of the Audi A2D2 Dataset, not Here Company Data was used because it was not provided/unavailable. The client proposed this alternative.
2. Developing and understanding
   1. During the first half of the ADS-semester, the team developed a sufficient set of skills to operate CNN-models. Reading into classifying multiple objects, it was decided that an RCNN would be an appropriate fit for the challenge of object detection. Having researched 2 different types of RCNN (YOLO & MASK-RCNN), transfer learning was applied and MASK\_RCNN turned out to be the best solution for object detection.
   2. Using the A2D2 tutorial and data, we researched the BUS Data (Meta data of the Lidar Car), as well as its mathematical functions. It is advised to read into Lidar before starting the project as it’s a fundamental aspect which is not directly provided during the semester. A2D2 Tutorial notebook serves this purpose well.
3. Running the detection
   1. Having chosen the MASK\_RCNN, it was applied for object detection, it is possible to annotate objects in an image with over 80 classes. It only does this when achieving a certain threshold of confidentiality. This resulted in an image, combined with an array which stores the coordinates of the edges of the annotation boxes, along with scores, colours, and other information (found in the MASK\_RCNN Git).
   2. After researching the array, a loop was writing which, as an input, takes a directory and annotates all images in that given directory. (Note that the notebook runs on Tensorflow 1.5, which is necessary, recommended is Tensorflow-GPU 1.5 for more computational power and faster results).
   3. By applying maths, the CenterPoint of each box (object) was calculated in X-Y Coordinates.
4. Running the Lidar
   1. Having achieved the object location in the images (box-coordinates), it was now time to find the Lidar points. Running code provided by Audi and tweaking it to the projects need, it was possible to plot all the lidar points on an image with their distance values. Per dot, a distance was stored, as well as the coordinates of that specific dot.
5. Overlapping the Lidar with the Objects
   1. The final step was determining the distance of each Object by combining the lidar with the detection. For this, the CenterPoint of each box was used to compare with the Lidar points. Using the Pythagoras Theorem, we calculated the distance between the Object CenterPoint and surrounding Lidar points. For each Lidar point we calculated the Hypotenuse, leaving us with a list of distances of each Lidar points in respect to the CenterPoint. By using the distance data from the closest Lidar point, it was possible to deduct the Lidar Car distance to the object. This was iterated for all objects in an image to determine the distance of all objects from the Lidar Car in an image.

## Further Development Recommendations

During research, the following steps could be taken to further develop on what has already been achieved:

1. Writing a function that iterates through an entire directory to overlay Lidar with object for actual Here Data.
2. Calculating the speed of detected cars over images.
3. Researching how CenterPoints that are intercepted by preceding cars can be accurately calculated. (Meaning correct Lidar Depth is used for that car instead of the one preceding)

## Conclusion

Our primary goal was met, detect object in the camera images and overlap the Lidar data to determine the distance between car & object. The initial goal, using the metadata to make calculations, was not met. That is why in a follow-up project, it would be recommended to carefully replicate the previous work on a smaller scale to create and understanding. From there the code could be reapplied to apply what was achieved in this project on a larger scale (larger set of images). Alongside, another recommendation is to research what calculations can be made with the meta-data to determine object attributes relative to the Lidar Car.