**Interviewer:** Can you please introduce yourself and your role in your organization?

**Interviewee:** So, my name is XXX and before I started my postdoc in January in 2021, I had been working for nearly two years at XXX that is global trucks technology as a functional safety expert. And my role was kind of very diverse. So partly, I was working as a function developer and then providing functional safety knowledge into IT when required and part I was also working as a researcher on topics relating functional safety, especially on the topic of context definition operational design domain for autonomous vehicles.

**Interviewer:** Great. Do you consider yourself more of academic person or industry related person?

**Interviewee:** I would consider myself more as an academic person.

**Interviewer:** Your total years of experience in the industry and how long you are in your current position?

**Interviewee:** I started at XXX in 2018. And I have been working there until December 2020. Now I'm on a two-year leave of absence. So, after my postdoc, the plan is to return to my industry. What I should mention is that I have been, in the beginning especially, working on more research questions in Volvo and have been part of a publicly funded research project in collaboration with universities and other industry partners. So that was more of a research nature than of what you would consider to classic industry work. But doing the last years, specially I have been heavily involved in function development for driver assistant system. So that would have been more what you would probably consider not academic but industry work.

**Interviewer:** Can you please describe your experience working with non-functional requirements in general?

**Interviewee:** Well, as a functional safety expert, functional safety as main suggestion and a lot that define to ensure that system we are building and operating in a safe way so that no one gets harmed. And this imposes significantly number of non-functional requirements on system safety requirements. And the work normally starts by if you have a new function for example, we have to identify the hazards, that like if the function does not behave it’s supposed to do, which hazard could occur and to prevent those hazards after we have identified them to prevent those hazards more currently defined safety goals that we want to achieve with the system, so we do not get into the situation of a safety problem. And based on the safety goals we derive so called functional safety concept where we have non-functional requirements on those function and that shall ensure that the system is behaving safe and those functional safety requirements, we break down into technical safety requirements that would by impose directly onto certain hardware components and that we judge a safety critical and software component that must not or shall not fail.

**Interviewer:** Do you think non-functional requirements play an important role for the success of a software and it can be genetic software or Machine Learning software, and if it is yes, how?

**Interviewee:** Yes, I think non-functional requirement play actually a key aspect of not only quality, but in terms of the success of a software. I mean you have functional requirements and those are coming from the use case descriptions or from the customers wishes for. But a customer, he doesn’t or he shouldn’t need to think to make all the safety security aspect that kind of run a little bit of a background to insure that this system is working as it was supposed to work and those are the essential parts of non-functional requirements. The customer wants to drive with the car from A to B, as an example, but he doesn't want to think about how to do that in a way that the car is behaving always safe, and no one can hack into the car and take over control of it. So, this is our job as system designer to think about these non-functional requirements like safety, security but also other aspects of privacy for example, becomes a very important aspect especially when you have highly connected systems as in cars becoming more and more popular to have connected to the internet. So, it's extremely important to the success of the product that these non-functional requirements are there and they are fulfilled and complete that they do not forget any safety critical non-functional requirement because that would be really bad.

**Interviewer:** Yes, that’s true! Do you think there are differences in non-functional requirements between generic software and Machine Learning enabled software?

**Interviewee:** My point of view is, if you have our traditional software product, they are normally very rule based, so that means if you have the supply input A, you have the rule saying input A than to B and that is kind of straight forward program. However, if you have Machine Learning and deep learning or neural network, then this is much more complicated because you cannot tell the neural network directly if input A to B instead you will present the neural network with a lot of training data and you ask the neural network that here is your training data so now you tell me the rule that you see in the training data. And then it has a rule trained and you give it data in runtime or in real time during the operation, and you hope it exactly the rule that you actually wanted to train on actually on is actually inside of your neural network. But it is not guaranteed really that you have exactly the rule you wanted and that makes a very hard from the safety point of view for example, because safety requirements of work that you’re confined are like boundaries on your system which can operate, quite hard that you say System operates all the setup of safety boundary then you shut the system off and you try to get this stop. But in Machine Learning you don't really know you cannot really set these boundaries in a neural network because mathematically it is too complex to prove this network is always behaving the certain way. That makes it much more challenging from the safety point of view.

**Interviewer:** Do you think there is some non-functional requirements which can be more prominent or important in Machine Learning context?

**Interviewee:** I think one non-functional requirement that is more prominent is probably privacy and anything that has to do with data handling, because Machine Learning bases on having data available for training and you will have, when you deploy a Machine Learning algorithm, you will have to collect data to check the performance of that Machine Learning algorithm and also to retrain it eventually. And this will impose certain data requirements and especially privacy requirements. This might be a much more significant than in conventional software products.

**Interviewer:** what do you think about the transparency or fairness in context of generic software and Machine Learning software? Is there any difference or more prominence in Machine Learning in regards of non-functional requirements?

**Interviewee:** Yes, this is a really good point. I read few weeks or months ago about this thing. It was a Smartphone app with camera, and it could detect faces, and this camera app used some form of neural network that has been trying to detect all different kinds of faces. But they showed that actually this app is able to detect more than 99 percent of white faces but only 80 percent of colored faces. Now in a camera app this might worth somewhere but it’s not really safety or any other problem but imagining you have automatic emergency Braking System bases on the visual camera and detecting of humans on the road. Now we have the headline of this camera system can automatically braking can detect 99% of white people but only 80% of colored people. Then we have a significant problem on our head. Not that the algorithm is working wrong or in a bad way, but it has been trained improperly with not correct training data or the training was not created or selected properly to ensure that the system performs in all situations correctly and this an extreme challenge that come up when you use Machine Learning with kind of safety critical systems. But you have to be sure that you're trained it properly and correctly according to your safety requirements and you have the requirement it should work for all people no matter what the skin color of this person.

**Interviewer:** Do you think some non-functional requirements are less important in Machine Learning context which were actually important in generic context?

**Interviewee:** No, honestly, I cannot think of any. I think rather it will be more non-functional requirements you mentioned this transparency, fairness, let us call them ethical requirements and data requirements, safety requirements would play a role but also security requirements which are if you would group of non-functional requirements, they will of course play a role as well. As an example, would of this possibility of the role you can trick a neural network by holding up some random pattern on a piece of paper and the system could recognize it as a stop sign for example it stops the vehicle. So now I don't think there is any in the non-functional requirement that would play a lesser role.

**Interviewer:** Do you think the non-functional requirement for the whole system or just for Machine Learning model or just data part?

**Interviewee:** From my experience, when you work for non-functional requirement you work top bottom principle. So, you have a very abstract view first, in functional safety we have this safety goals that you define and that is defined in the overall system that deploy certain functional that we want to put into the market. Then we break it down into these functional requirements which on the system view and then we break down into the technical safety in requirements which are already component-based and software component based. I think we will have to do the same with non-functional requirements of Machine Learning. so you have to have a more holistic view at first, and then you break it down until you arrive to the requirements you want. For example, the structure of the Neural Network.

So, you must start with the very big portion like as a whole and then you will have to split, and you must focus on a very small point. But you might get a new category that you didn’t have in functional safety for classical software or classical functions. You have to split between hardware requirement and the software requirements in the technical sector requirement on the lowest level, but may you get additional group, like for example requirements on the training data.

**Interviewer:** which challenges do you experience with non-functional requirements for Machine Learning?

Interviewee: I can tell you from the safety requirement point of view and one big challenge is that we are not able to guarantee the completeness of the non-functional requirement that we really captured or possibilities that Machine Learning algorithm could decide in certain situation that we can completely guarantee the safety of the system. In fact, the traditional software engineering is much easier because as I mentioned that this was very much rule-based, so you program the rules into the system and then you could very clearly or mathematically prove that whatever you do you will end in a safe situation and with Machine Learning or especially with deep learning when neural network, this is much more a challenge. It has not been completely solved yet.

**Interviewer:** As you said completeness of something, so do you think this completeness can be a non-functional Department?

**Interviewee:** Completeness mean that you completely cover all the possibilities how the system could react in a non-safe way. So, to guarantee safety, you have to guarantee that you also capture all possibilities that could go wrong in your system. And in some deep learning or neural network, you are never entirely sure if there might be some training data that you selected wrong that makes the system decide wrong in a certain situation. And the only way to kind of mitigate this problem a little bit is to do excessive testing of your newer network. But excessive testing is expensive and time consuming. While in traditional software coding, you could use some formal methods to prove that the software code you wrote is always behaving in a certain way.

**Interviewer:** Do you measure these non-functional requirements over Machine Learning enabled software?

**Interviewee:** Measure? Not that I'm aware of. I mean that, testing the system of course and based on those tests we decide whether it's safe or not, but in Machine Learning I'm not aware of any possible measure yet. I mean if you look at hardware components for example there you can measure the probability of a random hardware for example. Those who can done by statistical means, you take a lot of experiments, you measure a lot and then you get statistical values that tell you okay this is probability to hardware component will fail, how many of those hardware components will fail in a year. In software codes, it's already a little bit more challenging but normally you can measure how well your software code has been designed, how many links in your software, for example you have. But, for Machine Learning I would guess it would be some form of statistical measure that you will apply as well. You will probably provide in tests lot of input data to your trained neural network and then you will measure what is the decision that your neural network will take, maybe you will accept a certain number of wrong decisions over time.

**Interviewee:** Yes. So, in the context of measurement I can give an example. For example, if you consider accuracy, I can say that it is 99% accurate. So, we are measuring in statistical analysis so we can say that it will provide accurate results. Do you think for other non-functional requirements that we can measure in this way or another way?

**Interviewee:** I mean for safety requirements; it will be too much the way I mentioned for hardware. If you have the strictest hardware requirements, I think is that you can only have a random failure as a probability of 10^-9 per hour. So, it's extremely extremely low. And I think something similar you can define for neural networks probably as well, that the only problem then is of course that you have to provide a newer network with plausible input data that represents the operation that you actually want to do with the neural network. And that is what I meant when you need a lot of testing which is expensive.

**Interviewer:** And if you just imagine, you consider this measurement over the whole software or in just the Machine Learning part?

**Interviewee:** I think you will have to test your Machine Learning part separately and then you have to integrate it into your overall software then you do test again if that integration works well and the software works well together with the neural network that you trained. And then you have to integrate your software into the overall system, including like you have to deploy it on the actual hardware that you're going to use. You have to do the testing again to ensure that the safety requirements are still fulfilled.

So, it's classical V model. After you are in concepts phase, you get into your system design phase, you design a neural network, you train a neural network, and then comes the integration and testing phase and in the end, you hopefully have a safe and relievable product.

**Interviewer:** Do you think any kind of challenge of this kind of measuring?

**Interviewee:** Yeah, as I mentioned before, the biggest challenge I think is to provide a correct and plausible data that would be expected to also be representative of the used cases where you will deploy your system with the Machine Learning model. If we only have test data that is academic or does not represent the actual operation of the vehicle, then of course you cannot guarantee safety, because we couldn't test the neural network properly. Plus, you must be absolutely sure your test data and your training data that you used to are not in any way coming from the same data set. Because then you a very quickly run into the risk of of over fitting your training data if you don't have independent test data then you do not realize that you did over fitting and at will be two significant funny results from your neural network that are potentially extremely unsafe.

**Interviewer:** And how do you capture this measurement from the system?

**Interviewee:** Well, normally we have one requirement tracing tool. So, if we have certain non-functional safety requirements, we define test to prove that we fulfill this non-functional requirement. then the test has to be executed somewhere and the result of that test have to be logged into that tracing tool. So, in the end the aim is that you have from your safety goal that will define very well in the conceptual phase you can trace back all the functional or technical requirements, and then see ok that have been tested successfully with different tests and using different test environment and test data, and also trace back in case something was wrong that where the test has not been successful or has not been okay.

**Interviewee:** My predefined questions are finished actually. Do you have anything in this area to add?

**Interviewee:** Yes, I think very interesting is this discussion in terms of ethics and transparency or fairness of Machine Learning and I think it has a lot to do with how you train your Machine Learning algorithm or your deep neural network. And there will be a lot of research which needs to be done on how to properly select the training data and as now I am doing research on this contextual definition of Machine Learning algorithm and data quality attributes as well, and to one aspect I think that is not being discussed yet in this industry really is how to select exactly correct training data for the purpose that you want to have with your deep neural network or Machine Learning algorithm. Currently the approach is more like try to collect as much data as possible and through data on Machine Learning algorithm and let’s hope for the best as you want to do this happening. And this is extremely wrong, because not only you need way too much data which is a challenge itself to handle the data, but you also get for example, privacy issues; as you see Google and Facebook collect as much data as they can. Instead, it should be more planned, you should define what is the use case, what is the function that is neural network should do and then you explicitly select exactly that data that you need to train the neural network and limit the amount of data that you need for the training. And I don’t see any suitable process for that data in any company, how to do this selective data management for training neural networks.

**Interviewee:** For training, there are some data cleansing processes, so people are doing those data cleansing and they are throwing out some data which are not useful.

**Interviewee:** Yes indeed, I think this is only in the beginning. There should be much much more. Thank you for your interview, it has been very interesting, and you should definitely stay in contact or in collaborations because I think our research topics are overlapping little bit so it would be good.

Interviewer: Yes, sure. And thank you for your time.