Case study of integration of the fish bone chart in automotive industry on design and series production – engineering risk in ADAS

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Abstract
The global objective of this paper is to analyze engineering risk of series production in Automotive Industries based on problems caused by field returns by OEM Customers. The risks reval details of different levels and high risk can by caused when design and material was choose wrong in supplied chain of radar sensor products. On this paper, the method for engineering risk of management used is based on Fish Bone method adapted to causes identification and risk plan.

Keywords: ADAS, engineering of risk management, engineering risk, risk assessment, risk management.

1. INTRODUCTION

The preponderant tendency in automotive industry is to adapt permanently to the changes and introduce the market tendency in the new products that leads to customer satisfaction [1].

Understanding the automotive development life cycle is of paramount importance, before starting to construct any suitable tailored service process, which will be understood and accepted by the stakeholders. Effective process establishment "does not happen until an organization recognizes the need for it and the benefits it will bring them", i.e. [2].

The research of this paper is focused on the development of radar sensors according with mounting and guide lines. Therefore, the discussion suggests that the 'CM' in automotive radar sensors development projects starts directly after the freeze of FRS, which is the basis of the contract between OEM and supplier. If the research aims for the complete car development process the CM process start would probably be located at the Concept Requirement-Specification freeze. However, no harm done if the CM process start to early! The real benefit of the process is to collect the data describing the RfC and guide them through all the CM steps necessary to prepare the information required to take the adequate decisions with the best possible confidence and benefit for the business [3].

2. METHODOLOGY OF RESEARCH

A fishbone diagram, are called a cause and effect diagram or Ishikawa diagram, this diagram is a visualization tool for categorizing the potential causes of a issue in order to identify the root causes.

These tools can help to prioritize actions considerably and can be effective in increasing the value of those actions. Brainstorming is used for creativity and activating group thinking [4]. Fish bone charts specify the reasons of matters happen in a clear manner. In the AHP method by using pair comparison considerations and ranking them in a suitable manner, we can decide properly, and its output prioritizes the foregoing considerations by ranking method [5].

This method can transform the qualitative of a decision making problem into a quantitative form, and it also transforms mental assessments into relative values [6]. This tool is a measurement theory that deals with measurable criteria and unrealistic [5]. The AHP is very efficient for solving the problems, in which one option is used among the limited ones [5]. It is based on the following principles [5]:

1) Establishing a structure and ranking frame for the problem which in fact separates the complicated problems into similar ones.

2) Establishing the preferences through comparative pair. Comparative pairmatrix is usually used for assessment.

3) Establishing a logical compatibility for measurements. Desirable compatibility is provided in situations where incompatibility rate is less than 0.1. After specifying the priorities by the aid of comparative pair's matrix, we must review the compatibility of the specified priorities in order that the comments have desirable and logical compatibility [5].

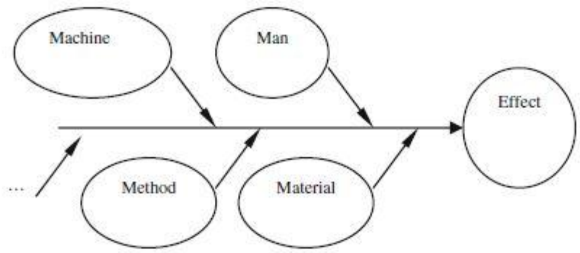

Figure 1. Chart of fish bone chart structure
Source [5]

3. MOUNTING AND GUIDE LINE FOR ARS RADAR SENSOR

ARS Radar Sensor Overview

In order to meet the increasing customer demands in terms of safety and comfort in the automotive industry, more and more vehicles have been equipped with a growing number of advanced driver assistance systems (ADAS) in recent years. Furthermore, the Euro NCAP requirements are a major driving force in the market. The vision of highly automated driving draws nearer with each system expansion and the associated expansion of the functional spectrum of a vehicle. Beside ultrasonic, cameras and the upcoming lidar systems, especially radar based sensors will play a key role to implement various safety and comfort systems because of their reliable results independent to weather and lighting influences [7]. In order to introduce radar based ADAS functions, such as blind spot detection or the lane change assist, into the volume segment and to equip premium vehicles with more complex features, the price-performance ratio respectively sensor performance can be improved through the following approaches [7]:

1) highly integrated components (HF-Rx/Tx circuit, A-D converter self-diagnosis, digital interface) for more compact, economically constructed sensors.
2) high-performance microcontrollers (with more cores and memory for example) to implement more complex algorithms.
3) expansion of the available bandwidth by using a higher frequency range and innovative modulation concepts (76 to 81 GHz).

The new sensor architecture, please see on the **Figure 2**, is the first to use the RF CMOS based 77-GHz technology. The system uses SPI to initially transmit the parameters for the frequency modulation of the radar signal to be emitted. This may vary depending on the driving situation and function due to different requirements on range and resolution. Thus, a park-ing.function at close range for example demands a different configuration than an intersection assist function, which also requires greater ranges. Different bandwidths and measurement periods used to operate the radar system chip result accordingly. The generated signal is transmitted separately via three anten-nas, which are available as etched con-ducting paths on the circuit board [7].

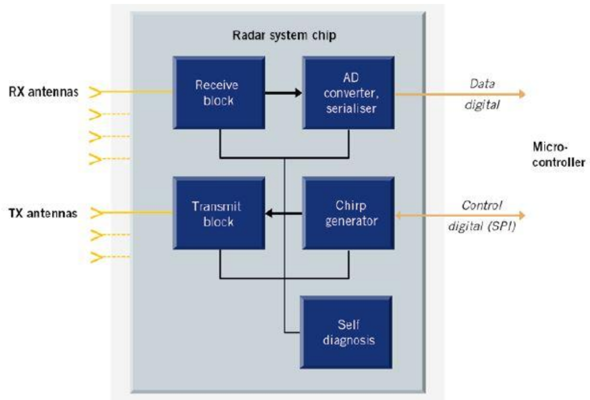

Figure 2. Schematic layout of highly integrated circuits for radar sensors (© Hella)
Source [7]

ARS Mounting Requirements

The sensor can be mounted in normal or flipped orientation. I. e. each sensor can be mounted on the left or right hand side of the vehicle, connector facing downwards or upwards direction [Defined in Vehicle specification] but in same direction on both sides of the target vehicle platform. The sensor must be protected from direct impact of water/mud/snow [8]. On the next steps are resume the important things which we needed to take in consideration for this topics: bumper design, secondary surface, on below is this important steps:

1) Distance from sensor to bumper - on this step are needed to request from customer the tolerances ;
2) Build the radar cones with all tolerances: flatness tolerance of the bracket, align tolerances (±6°), additional margins (±6°) and
positional tolerances - on this topic are needed to request from customer ;
3) Calculate the surface area in front of the sensor based on the radar cone ;
4) Request from customer important information about material layers: (a) thickness of every layer, (b) material of every layer - paint is a layer;
5) Request from customer the secondary surface design;
6) Request from customer the surrounding components of the sensor;

Mounting Location Requirements

Requirements according with mounting and guideline for horizontal deviation based on vehicle axis:
1) Up to 600 mm out of vehicle center;
2) From 600 mm to 900 mm out of vehicle center, with performance limitations for full speed range ACC function;

Requirements according with mounting and guideline for Vertically deviations based on vehicle axis:

1) From 295 mm to 800 mm above road-surface level;

2) From 800 mm to 1000 mm above road-surface level with performance limitations;

Addtional notes:

1) Performance limitations for full speed range ACC (FSRA) function should be expected if positioned at outer edge of specified range.

2) Values measured from sensor center.

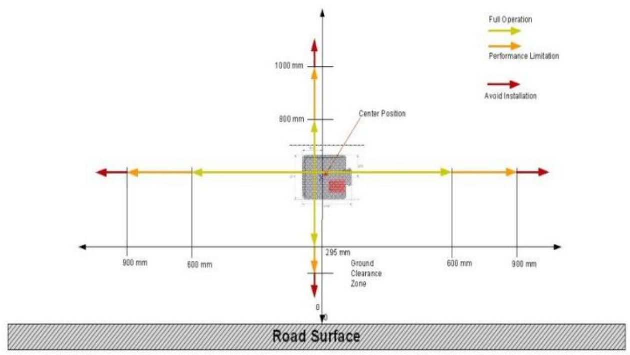

Figure 3. ARS radar sensor requirements mounting and guide lines

The industrial development in Romania includes ADAS sector, a sector which grows up in every year. The main projects are focused on the bracket projects in sensors. In this case study we are talking about one project for bracket radar sensor, the type of radar sensor that is an ARS (Advance Range Radar) sensor [8].

4. RESULTS OF RESEARCH

In case study the engineering risk management is directly related to fish bone chart for identifed risk and monitorized risk. The scheme for identification of this root cause as ilustrated in Figure 4.

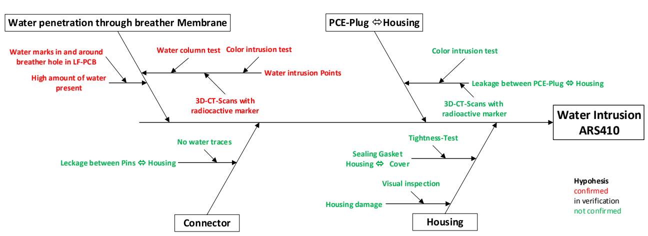

Figure 4. Chart of fish bone chart structure made by sensor team

On this research was involved R&D department and production plan, together with laboratory of quality to identified the cause of the field return. This field return was came from OEM customer because they had water intrusion into the sensor and function of radar sensor was shutting down. We talked about mounting and guidelines for sensor needing an overview and on radar design was take into consideration requirements for breather function for avoidance condensation and finally corrosion. On the Figure 5-7 the situation of water intrusion in sensor is illustrated, as in this situation was used fish bone chart for determination root cause powered by radar sensor team at Continental Automotive Company. Sensor team was tried to found how does water get into the sensor. This radar sensor are located in front vehicle behind bumper.

1) Water comes in vehicle through the ventilation slots

Figure 5. Ventilation slot where water through in vehicle

Most of the water is delivered directly to the sensor via the front grille. The water can come from precipitation of any kind, when washing the vehicle or by spraying the soil water.

2) The ventilation slots fill up and water stops at the breather membrane

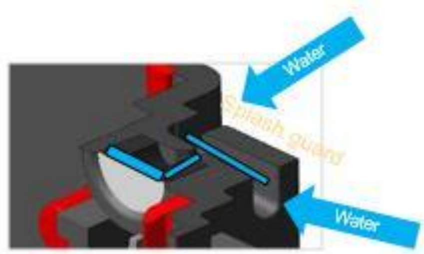

Figure 6. The way how water through into breather membrane

This pressure equalization concept is provided with a membrane.

3) Water penetrates the membrane of breather

Figure 7. Preassure equalization element with membrane

First cause was indentified, in fact radar sensor from generation ARS4xx warms itself during operation, pressure compensation through breather. After that accumulation of water in breather channels and covers fully membrane surface (eg. at cars with low mounting position). Radar sensor was shut down, cools down and breathing over membrane was not possible (because was fully covered with water), under pressure in sensor is possible up to 0.25bar. Water fully covers breather membrane and is been sucked through membrane due to under pressure into the radar sensor, finally water leads to a shortcut and/or corrosion.

5. CONCLUSIONS

In this case of study we identified the problem of corrosion and root cause of radar sensor why was shutting down. On the figure below are showed theory of water intrusion.

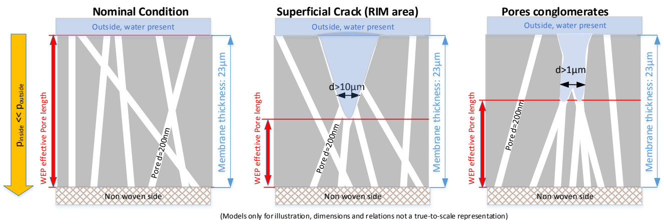

Figure 8. Water passes through pores of reduced length or holes from membrane

On the Figure 8, was showed how water through on the membrane. These causes was identified based on REM Microscopy.

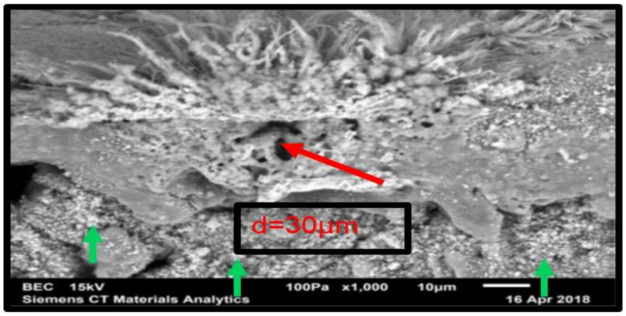

Figure 9. Pores conglomerates after FIB cuts and REM Microscopy analyzed.

Based on results and experience design department and system architect from ADAS department we concluded, after a good evaluation report from laboratory, that we needed to take in consideration every scenario. Our team concluded:

1) Again no cracks or voids in Light or REM Microscopy in Membrane identfied;
2) Pores conglomerates generate big pores (here: 2µm = 10 x nominal pore diameter 0.2µm);
3) Pores conglomerates only reliable detectable with FIB cuts;
4) Superficial Light or REM Microscopy not able to visualize Pores conglomerates;
5) This membrane shall be replaced with another one from another supplier and to shift position of the membrane on the back side on the sensor, instead current design where the membrane are in the front of the sensor.

In order to avoid the problems in quote phases we needed to try an implementation as engineering of risk management in Supply Chains has gained increasing attention over the last years [8]. At the same time, the pressure to consider social issues in global and interconnected supply chains has risen as well. These issues pose risk to supply chains since their occurrence may lead to a bad reputation that would, in its turn, cause adverse stakeholder reactions [9].

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