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# Risk Analysis in the Automotive Industry

*The automotive industry is one of the most dynamically growing fields of the manufacturing area. Besides this, it has very strict rules concerning safety and reliability. In our work, our aim is to point out the importance of the automotive industry (based on statistics) and the rules in connection with risk and root cause analysis. The most important risk analysis method is the Failure Mode and Effect Analysis (FMEA). According to standards and OEM regulations, FMEA is obligatory in the automotive sector. In our study, we summarise the area of FMEA usage, its types and process steps.*

***Keywords:*** *risk analysis, Failure Mode and Effect Analysis, Risk Priority Number*

## Introduction

In our work, our aim is to point out the well-known fact, that the automotive industry is constantly developing, although it is strongly influenced by the economic environment. According to statistics, the Hungarian automotive industry resulted in the following numbers:

- production value of 26.1 billion EUR (in 2017)
- 13% of production value increase (in the period of 2010–2017)
- 28.7% of manufacturing output increase (in 2017)
- 175,800 people employed in the sector (4% of the total employment)
- 500,000 manufactured cars (in 2017)
- 5 OEMs have already chosen Hungary (Mercedes-Benz, Audi, Suzuki, Opel, BMW)
- 700 automotive supplier companies
- over 40 of the top 100 OEM suppliers are represented
- 20% of Hungary's total export [1]

Table 1.
*Figures of Hungarian OEMs, 2017* [1]

| Company name | Number of employees | Car/engine production |
|---|---|---|
| Magyar Suzuki Corporation | 3,100 | 176,705 (cars) |
| Mercedes-Benz Manufacturing Hungary Ltd. | 4,000 | ca. 190,000 (cars) |
| Opel Szentgotthárd Ltd. (PSA) | 1,251 | 486,302 (engines) |
| Audi Hungária Ltd. | 12,307 | 105,491 (cars)<br>1,965,165 (engines) |

Currently, there are 4 OEMs operating in Hungary and a BMW plant is being built:

- Magyar Suzuki Corporation (Esztergom), with a yearly production of 176,705 cars
- Mercedes-Benz Manufacturing Hungary Ltd. (Kecskemét), with a yearly production of 190,000 cars
- Opel Szentgotthárd Ltd. (PSA) (Szentgotthárd), with a yearly production of 486,302 engines
- Audi Hungária Ltd. (Győr), with 105,491 cars yearly and 1,965,165 engines produced [1]

The numbers mentioned above point out, that the automotive industry is a leading industry branch even locally. (Although, it is important to state, that despite the presence of OEMs, Hungary is the country of automotive suppliers.)

As the automotive production is a serious responsibility, there are surplus rules to follow (according to IATF, etc.). According to these mandatory quality requirements, risk analyses have to be carried out (Failure Mode and Effect Analysis) in terms of product planning and manufacturing processes. Root cause analysis is connected to FMEA. (The complaints of internal/external customers are handled in 8D analyses.) 8D is a systematic analysis in which the root causes of non-conformities are defined.

Our second aim is to emphasise the importance of quality analysis tools. Analysis methods are important in the automotive industry, as safety has to go first.

## Global Automotive Overview

As we have pointed out in the Introduction section, the automotive industry has a significant role globally, and locally as well. This importance can be seen in the manufactured quantity, in export figures and employment rates.

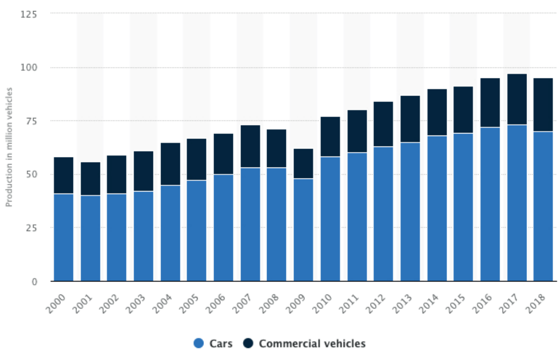


Figure 1.
*Global automotive production (2000–2018)* [2]

On Figure 1, it can be seen that in 2018 approximately 70 million cars and 20 million commercial cars were produced [2]. The tendency of automotive production is increasing, although the economic background is strongly influencing it.

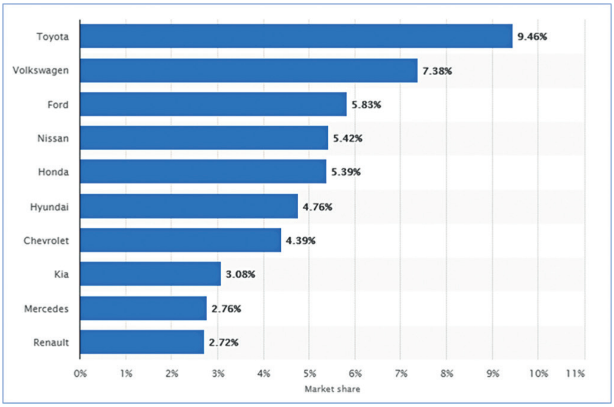


Figure 2.
*Global automotive market share* [3]

Amongst the top manufacturer companies, Toyota has a market share of approximately 10%, according to Figure 2. This significant market share resulted in 260 billion USD revenue in 2017 [3]. On Figure 3, the automotive action groups are shown, to which the companies of Figure 2 belong.

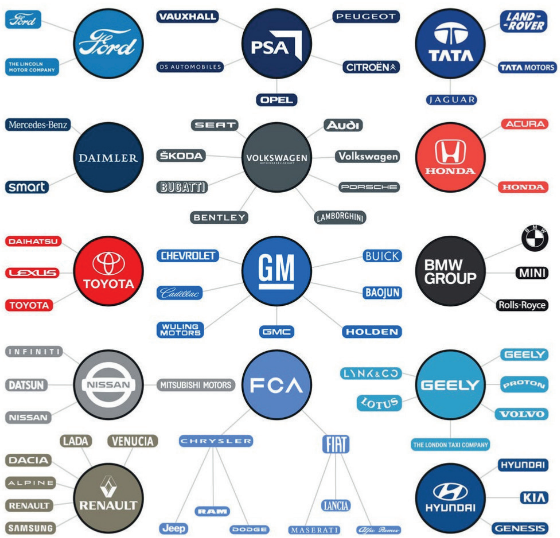


Figure 3.
*Automotive manufacturer groups* [3]

The mentioned automotive connections seen on Figure 3 are important to know, because each manufacturer group has its own requirements towards its suppliers. In Hungary, PSA (Opel), Daimler (Mercedes Benz), Volkswagen (Audi), Suzuki and BMW are present [3].

## Analysing Risk with Failure Mode and Effect Analysis

As mentioned before, FMEA is obligatory in the automotive industry. Both AIAG (Automotive Industry Action Group, which is a North American manufacturer group) and VDA (Verband der Automobilindustrie, which is a German manufacturer group) created a regulation on FMEA. Because of the changed mindset, AIAG and VDA created a common handbook in order to eliminate the differences in both methods. IATF 16949:2016 (the surplus criteria of ISO 9001:2015 for automotive producers, which replaces ISO/TS) also states that it is mandatory. (Even OEMs created their own regulations and handbooks.) [4]

FMEA is a systematic analysis for defining possible risks of systems (System FMEA), products (Design FMEA), processes (Process FMEA) and services (Service FMEA). On the one hand, the aim of FMEA is to identify potential risk possibilities, in order to avoid them. On the other, FMEA is used for the evaluation of already occurred failures.

These analyses are strongly connected to each other:

- System FMEA consists of several Product FMEAs (these can be SW products, as well)
- Design FMEA failure effects are linked to Process FMEA failure modes (as it is important that each failure mode has an effect on the process level and on the design level, as well) [5]

As shown in Table 2, a car can be considered a system, which consists of several units, like brake system ECUs. In this example, this ECU is the product. Process FMEA is about the ECU's manufacturing process. FMEA evaluation is currently based on the Risk Priority Number (RPN).

Table 2.

*System–subsystem connection in cars* [6]

| System | Subsystem |
|---|---|
| Vehicle | Transmission system |
| | Exhaust system |
| | Engine |
| | Braking system→ product ECU |
| | Steering system |
| | Suspension system |
| | Electrical system |
| | Cooling system |
| | Fuel supply system |

RPN is the multiplication of the following factors:

- S (Severity): failure effect severity (the significance of the failure effect)
- O (Occurrence): failure cause occurrence
- D (Detection): failure cause detection [5]

Each factor has a maximum value of 10, which means that the highest RPN value is 1,000. (This means that the most serious non-conformity is rated with 10, the failure cause occurring the most  is rated with 10, and the failure cause most likely to be detected is rated with 1.

FMEAs are systematically created; they consist of the following steps (according to the VDA):

1. Structure analysis (the basic parts of examination are defined and separated)
2. Function analysis (written requirements of system, product or process)
3. Failure analysis (definition of failure nets, centred on failure modes)
4. Definition of measures (initial state)
5. Evaluation of S, O, D factors (actions for process improvement) [5]

As FMEA is a living document, all feedbacks and data have to be implemented in the analysis (concerning product structure and manufacturing process evaluation, as well). Safety is the most important feature in connection with automotive production (as the S = 10 means that fatal injury can happen in case of failure.)

## Summary

Hungary is a country of automotive suppliers, who are providing components (both mechanic and electronic) to OEMs worldwide. In our work, we have pointed out the significance of automotive industry on the basis of statistics, concerning world, EU and domestic production. The most important data are those which affect the current status of Hungary (the production and employment values of the OEMs settled in the country).

Since in the automotive sector safety is prior to anything else, it applies mandatory methods for improving quality. Failure Mode and Effect Analysis is one of these tools, it is applied on system-, product-, and process levels as well. Our aim was to describe the method, its process steps and area of usage.

As the part of the research, different aspects of the FMEA will be examined: Process FMEA extension possibilities, usage of fuzzy methodology.

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***Kulcsszavak:*** *kockázatelemzés, hibamód- és hatáselemzés, rizikó prioritási szám*

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