Development of a tool for EMC validation of front camera sensors

/ Department of
Mathematics and
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/ PDEng Software
Technology

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Grace Annabel Vasu

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Eindhoven University of Technology
Stan Ackermans Institute – Software Technology

PDEng Report: 2018/087

The design that is described in this report has been carried out in accordance with the rules of the TU/e Code of Scientific Conduct.

Public

Partners

Valeo Schalter und Sensoren GmbH

Eindhoven University of Technology

Steering Group

Bernd Biehlman
Yanja Dajsuren
Gijs Dubbelman
Bernd Holste
Grace Annabel Vasu

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Contact address
Eindhoven University of Technology
Department of Mathematics and Computer Science
MF 5.080A
P.O. Box 513
NL-5600 MB
Eindhoven, The Netherlands
+31 402474334

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Abstract
Electromagnetic Compatibility Validation is required for all front cameras produced by Valeo. This report details the analysis, design and development of a tool for EMC validation of front cameras. The tool can be adapted to work for any Valeo front camera. This report also contains an adaptation guide and a user guide. Further, it details the process that should be followed when adapting the tool for a new project.

Keywords
EMC Validation, Front Camera, Requirement Analysis, Software Architecture, Software Design, Adaptability, Valeo, PDeng.

Preferred reference
Development of a tool for EMC validation of front camera sensors. Eindhoven: Technische Universiteit Eindhoven, 2018. (PDEng report).

Partnership
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Foreword

The Valeo Switches & Detection Systems located in Bietigheim-Bissingen, Germany belongs to the Comfort and Driving Assistance Systems Business Group of Valeo. It mainly focuses on research and development in the field of autonomous and automated driving, such as parking assistance systems, steering angle and engine management sensors, radar, lidar and laser scanner technology, rain sensors, image processing systems, steering column switches and switch modules.

Within the automotive industry, the demands on used parts are typically much higher than on ordinary consumer products, due to the wide operational conditions, within a car can be used. The inclusion of new technologies in automotive systems and the growing complexity of the systems on one side, and the growth of wireless technologies on the other side have resulted in new challenges regarding the Electromagnetic Compatibility of all used systems inside a car. Electromagnetic compatibility (EMC) is the concept of enabling different electronics devices to operate without mutual Electromagnetic Interference (EMI), when they are operated in close proximity to each other.

Testing the functionality of image processing system like an automotive front camera regarding Electromagnetic Compatibility is a very complex subject, due to its numerous input and output signals and the complex algorithms that are applied on the camera images. All of that is normally hidden to the driver of a car, but has to be checked in order to verify, if the camera system is working properly. This complexity and the first experiences with automated EMC testing of automotive camera systems made at Valeo, has led to the task given to Grace Vasu, to develop a robust software system for that purpose that also should be able to be used for future projects and customers without making extensive changes.

Grace already brought a very good knowledge of software architecture, design and development with her, when she started her work on the EMC test system. Additionally, it was easy for her to gain the necessary knowledge about the automotive CAN bus technology in general and the quasi-standard CAN tools from Vector that are widely used within the automotive industry inside and outside of Germany specifically. Grace was able to accomplish her task successfully and to fulfill most of the stakeholder requirements. The result of her work has been demonstrated and verified in an EMC test setup, similar to the setup used at the EMC lab at Valeo, for an existing front camera customer project and is ready to use for future projects, just like intended.

Grace is a pleasant person to work with and she showed good communication and presentation skills in her daily work. Her work is very focused and committed on the deliverables to be achieved. Based on my experiences with Grace at Valeo, I am sure that she will be a very good software engineer in future. I am pleased that I was able to support her as a mentor and I wish her all success in her future industrial career.

Bernd Holste, Software Engineer at Valeo Switches & Detection Systems

September 2018

Preface

This document is a technical report of my final year project for the Professional Doctorate in Engineering (PDEng) in Software Technology(ST) at Eindhoven University of Technology. The PDEng program is part of the 4TU.School for technological design, which is a joint initiative of the universities of technology in the Netherlands.

The PDEng ST program is a two year program. During the first 14 months, the trainees undergo advanced training in order to enhance their technical and non-technical competencies. This includes three industry projects where the trainees are given an opportunity to take on various project related roles. The next 10 months is spent on individual graduation projects where the trainee is expected to put the skills learnt in the program into practice.

Valeo Schalter und Sensoren GmbH provided two projects for final year candidates of the PDEng ST program. The aim of the projects is to increase reuse of software tools among internal projects at Valeo. I had the opportunity to do my final year project at Valeo. The aim of this project is to create a tool or a software architecture for electromagnetic validation that can be adapted to work on all Valeo Front Camera projects.

The target audience of this report is anyone who is interested in software design, automotive testing and/ or electromagnetic testing of automotive components.

Grace Annabel Vasu

October 26, 2018

Acknowledgments

I would like to thank my supervisor from Valeo, Bernd Biehlman, for giving me this challenging project. I would also like to thank my project mentor, Bernd Holste, for his advice during the project and for introducing me to people at Valeo involved in EMC validation.

I would like to thank three developers from St Petersberg - Mikhail Abramov, Anton Golovin, and Anton Salnikov, who spent half an hour every week answering my questions and giving me feedback. Without their help, this project would not have been successful.

I am thankful to the staff of the Technical University of Eindhoven for their support. Gijs Dubbelman, my TU/e supervisor, monitored the progress of my project and gave me feedback during the project steering group meetings. Yanja Dajsuren and Peter Heuberger along with Hector Montemayor (Valeo) initiated the understanding between the TU/e and Valeo, and did their best to reduce delays at the start of the project. Desiree van Oorschot and Ellen van Hoof-Rompen helped with the logistics of moving to Germany. They gathered the documents required for my visa application, which made moving a lot easier!

I am thankful to my family and boyfriend for support and encouragement.

Executive Summary

The automotive industry is undergoing tremendous change due to autonomous driving. An autonomous car is a car that can drive itself, without human intervention. Such a car would need to have various sensors in order to perceive its environment. One such sensor is a front camera, which is placed above the rear view mirror on a self-driving car.

Valeo produces front cameras which are used to realise partial automation. For example, a function called Autonomous Emergency Braking (AEB) is used to make the car brake when it is about to collide with an obstacle in its path.

The front cameras are susceptible to electromagnetic interference. A phone placed in a car or other components in the car, can potentially cause interference, which can cause the camera to malfunction. EMC testing is carried out in labs at Valeo, in order to detect whether the camera fails in the presence of electromagnetic interference. Valeo does not have a standard tool for EMC testing. For each new customer, the front camera specification is different and so the tools are made from scratch.

The Valeo front camera is being transformed into a platform. What this means is that the technology and tools for the camera will not change. For each customer, the same platform will be altered in accordance to the customer requirements. This implies that all the front camera tools, including the EMC validation tool, should be generalised.

The main goal of this project is to create an EMC tool that can be used for validation of any front camera. The current tool should be analysed and portions that can be reused must be identified. If it is found that such a tool cannot be created, a tool that can be adapted for any project should be created.

The result of this project is an EMC validation tool that can be adapted to work for all of Valeo's front cameras. The requirements analysis, architecture and design of the tool was created in accordance to the ideas taught in the PDEng courses.

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1 Introduction

This chapter discusses the context of the project, the main goals and an outline of the report.

1.1 Project Context

The automotive industry is undergoing tremendous change due to autonomous driving. An autonomous car is a car that can drive itself, without human intervention. It is predicted that before 2022, fully autonomous cars will be sold to the public. In fact, the world's first Self-Driving Taxis was launched in Singapore in 2016.

Many technology companies, such as, Google, Intel, Apple, and Microsoft have showcased self driving cars . Major automotive manufacturers, such as, BMW, Audi, and Volvo are partnering with these technology companies to create self driving cars.

Figure 1.1 shows the components of a typical autonomous driving car. It has five core components [13]:

- Perception: A human driver would use their eyes to see the world around them. A self driving car uses one or more cameras for this purpose. There is usually a camera in the front of the car, just about the front mirror, called the Front Camera. Complex image processing algorithms are used to identify objects that the front camera sees.
- Sensor Fusion: Sensors, such as ultrasonic sensors, LIDAR and/or Radars are used to detect obstacles in the environment. Data from the camera and the other sensors are used together in order to validate and/or supplement what the camera sees. A combination of sensors are used to create a good understanding of the environment that surrounds the car.
- Localization: It is important for a self driving car to know where it is located. This is usually done using complex algorithms that take inputs from GPS, maps, LIDARs and other sensors.
- Path Planning: In order to drive from point A to point B, a path between the two points is planned, including the manoeuvres required to travel along the desired path.
- Control: The control or actuation component executes the manoeuvres that are required to follow the planned path. This includes accelerating, braking and steering when required, based on a signal from the car. All cars already have this capability, namely, drive-by-wire, steer-by-wire and brake-by-wire.

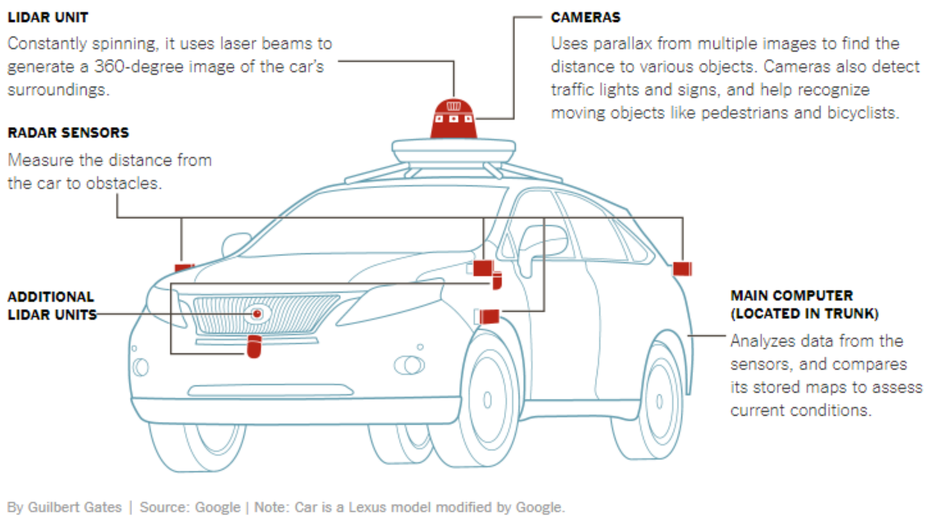

Figure 1.1: Components of an autonomous car

There are five levels of automation, as defined by the SAE. A higher level of automation means more automated functionality and lower interaction between the driver and the car [7].

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
Human driver **monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system **("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 1.2: Levels of autonomous driving as defined by the Society of Automotive Engineers [7]

1.2 Project Scope and Main Goal

Valeo is a Tier 1 automotive supplier head-quartered in France. It consists of four business groups:

- Thermal Systems
- Visibility Systems
- Powertrain Systems
- Comfort and Driving Assistance Systems (CDA)

1.2.1 Valeo Front Camera

The Valeo Front Camera is a component that is manufactured by the CDA group. The CDA group is located in Bietigheim- Bissingen, Germany. The Front Camera is used by OEMs to realize functions that are required for driving assistance and partial automation (SAE levels 1 and 2 respectively). Valeo has tie-ups with OEMs to produce front cameras for their cars.

1.2.2 Project Goal

The Front Camera projects at Valeo are executed on very tight schedules. Some of the software tools that are used for each camera are not well defined. For each project, new tools are made, without considering reuse of tools. This leads to a lot of duplicate work. The Front Camera team wants to examine software tools and try to standardize them in order to save time and money.

The main goal of this project is to create a tool for Electromagnetic Compatibility (EMC) validation of the front camera for all current and future projects. This could mean to create a tool for EMC validation that works for all projects or to create a general architecture for the EMC validation tool and implement it for one project. If a general tool is created, it should be easy to adapt it to front camera projects.

1.3 Outline

The project was divided into two phases - the analysis phase and the design phase. The analysis phase included stakeholder, domain, problem, and requirement analysis and is outlined in chapters 2-5. The design phase included architecture, design and implementation which is not described in this public report. Please refer to the confidential report for more details about the project, inclduing the architecture, design, implementation, user guide, and adaptation guide.

2 Stakeholder Analysis

Stakeholder Analysis was carried out in order to identify and analyse people or organizations that are interested in the project. An interview was conducted with each identified stakeholder in order to determine the following:

- Role(s) and Responsibilities during the project
- Acceptance Criteria
- Goals they have for the project
- Expectations
- What they like about the current tool?
- What issues they face when using the current tool?
- What they would you like to change about the current tool?

Table 2.1: Stakeholder Analysis - Hector Montemayor

Hector Montemayor [Project Technical Manager]	
Goals	• Try to have a unified solution for Electromagnetic Compatibility and Environmental validation across all cameras for all projects. • If the above goal is not possible, there should be an explanation regarding why it is not possible. • A dedicated person to analyse and come up with a solution because right now the tool is patched up in a very stressed out environment. • The tool should be adaptable for the next camera project. • Collaboration between the TU/e and Valeo.

Continued on next page

Table 2.1 – *Continued from previous page*

Acceptance Criteria	• The tool should work for the next front camera project. • Design decisions should be explained. • Demonstrate a working tool by the end of the project.
Tasks & Roles	• Attend PSGs. • Provide feedback on deliverables. • Review reports if time permits.
Involvement	• PSG meetings. • Review of reports if time permits. • Updated weekly through status reports.

Table 2.2: Stakeholder Analysis - Shinya Okina

Shinya Okina [System Team Leader]	
Goals	• Try to have a unified solution for EMC, ENV validation across all cameras for all projects. • Ensure that the knowledge of the system team is used in EMC validation.
Acceptance Criteria	• The EMC users are happy with the tool.

Continued on next page

Table 2.2 – *Continued from previous page*

Tasks & Roles	• Support in case of technical issues. • Can answer technical questions. • Guide and review .
Involvement	• Involved in the PSG meetings. • Review of reports if time permits. • Will be updated through weekly status reports.

Table 2.3: Stakeholder Analysis - Nazim Benabdesselam

Nazim Benabdesselam [Project Technical Manager]	
Goals	• Manage to have what is needed implemented. • The current implementation has a lot of messy code. Ensure that this is not the case for the new implementation. • At the end a tool that works which needs few adaptations for subsequent projects.
Acceptance Criteria	• Working tool that only needs a bit of adaption for a new project. • Understands that it may not be 100 % modular.
Tasks & Roles	• Review deliverables.
Involvement	• Review deliverables.

Table 2.4: Stakeholder Analysis - Bernd Biehlman

Bernd Biehlman [System Team Leader]	
Goals	• In the end to analyse and understand the stakeholder. • Identify what is feasible. • Tool should be flexible so that it can be adapted for every camera. • Make the end user happy.
Acceptance Criteria	• Flexibility of the tool (ideally). • A feasibility study explaining design decisions. • If the tool is not flexible, the feasibility study should explain why it is not possible.
Tasks & Roles	• Mentor. • Evaluate. • Provide feedback. • Review deliverables.
Involvement	• PSG meetings. • As a mentor, as and when required. • Provide resources or support as required. • Will be updated through weekly status reports.

Table 2.5: Stakeholder Analysis - Thorsten Meyer

Thorsten Meyer [Platform team architect]	
Goals	• When I leave, that I am happy with the opportunities that I received. • The EMC tool should take inputs from the system architect.
Acceptance Criteria	• The result of work is reusable meaning documented and adaptable. • The tool should include a document on how to adapt it. • Tool should include a user guide. • The tool should be the standard that is used for upcoming camera projects.
Tasks & Roles	• Review deliverables.
Involvement	• Review deliverables.

Table 2.6: Stakeholder Analysis - Gijs Dubbelman

Gijs Dubbelman [TU//e Supervisor]	
Goals	• To supervise the project. • Solve problems when there is a bottleneck.
Acceptance Criteria	• Communicate when necessary. • Report issues as soon as possible. • Defend design decisions.

Continued on next page

Table 2.6 – *Continued from previous page*

Tasks & Roles	• Provide feedback when there are issues. • Guide when necessary.
Involvement	• Work together when there is a bottleneck. • Help arrange training if necessary. • PSG meetings.

Table 2.7: Stakeholder Analysis - Yanja Dajsuren

Yanja Dajsuren [PDEng ST Program Director]	
Goals	• The trainee qualifies the PDEng graduation criteria. • Good relations between Valeo and TU/e. • Put the knowledge gained from the courses into practice.
Acceptance Criteria	• Technical report that follows the guidelines set by the university. • Good evaluation by the PSG committee.
Tasks & Roles	• Evaluate trainee.
Involvement	• Will attend some of the PSG meetings. • Evaluation.

Table 2.8: Stakeholder Analysis - Grace Vasu

Grace Vasu [PDEng Trainee]	
Goals	• To be satisfied with the results of this project by using my skills to develop a good architecture, design, implementation and validation. • To work consistently. • Finish the project in time.
Acceptance Criteria	• Report on project progress regularly. • Design choices should be defended well. • All blocking issues should be reported and handled in a way that reduces the impact of these issues on the project.
Tasks & Roles	• Report regularly to stakeholders. • Manage the project - make a project plan, execute it, review the plan regularly. • Design the tool - analyse requirements, perform feasibility study, consider design alternatives. • Document the project regularly.
Involvement	• Involved in all aspects of the project realization.

Table 2.9: Stakeholder Analysis - Bernd Holste

Bernd Holste [Software Engineer]	
Goals	• A working tool that can be used for current projects and that only needs small adaptations for using in future projects. • Parts from the existing tool that are good should be reused, bad parts/structures should be replaced/ fixed. • EMC users should be able to operate the system in the end.
Acceptance Criteria	• The tool is working in the EMC lab for the current VW front camera project, together with the existing setup. • the result of the work is well documented. • Tool should contain a description on how to adapt it for subsequent projects. • Tool should contain a good user guide.
Tasks & Roles	• Guidance. • Supervision. • Provide feedback. • Review deliverables. • Provide necessary help and contacts. • General support as required.

Continued on next page

Table 2.9 – *Continued from previous page*

Involvement	• Weekly meetings. • Updated through weekly status reports. • Involved in PSG meetings. • Suggestions for final report. • Review of report.

3 Domain Analysis

This chapter introduces the front camera, its functions, and EMC validation of the Front Camera.

3.1 Front Camera

The front camera produced by Valeo is a critical component in the realization of driving assistance functions, explained in the next section. The front camera is placed directly above the front mirror and has a good view of the environment in front of the car.

The front camera consists of three key components, as shown in Figure 3.1:

- EyeQ Chip
- Host Processor
- Imager

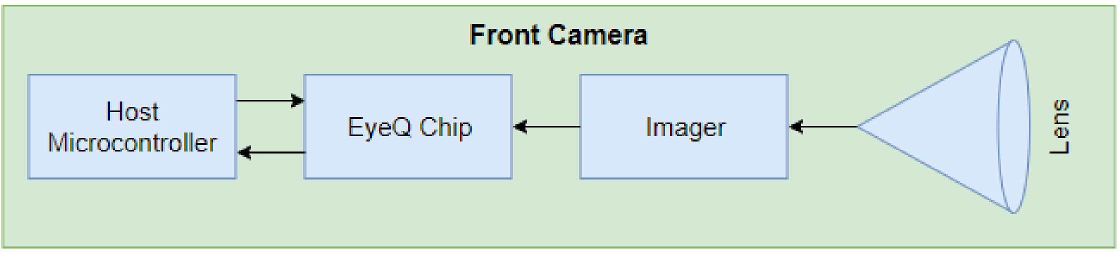

Figure 3.1: Front Camera Block Diagram

When light enters the camera through the lens, an image of the surroundings is formed on the imager. The image is sent to the Mobileye EyeQ chip for processing. The EyeQ chip contains sophisticated Image Processing Algorithms that help identify the objects in the image. For example, traffic signs, road lanes, other vehicles and pedestrians are identified. The EyeQ chip sends details about the objects to the host microcontroller. The host, in turn, processes this information further, and sends the results from the camera onto the CAN network.

3.2 Front Camera Functions

- Traffic Sign Recognition (TSR): TSR is a function that recognizes traffic signs, such as, speed limits, stop signs, etc. The traffic signs identified by the camera are usually displayed on the dashboard.

- Autonomous Emergency Braking (AEB): The AEB function prevents the car from colliding with obstacles that may be in its path. The Front Camera identifies obstacles and sends information about this on the CAN bus. An obstacle can also potentially be identified by the RADAR, LIDAR, ultrasonic sensors etc. Hence, information about an obstacle, from all sensors, is integrated in order to obtain consistent data. This process is called data fusion. Once data fusion occurs, AEB may occur to prevent the car from colliding with the identified obstacle.

- Traffic Jam Pilot (TJP): TJP assists the driver in heavy traffic conditions and is usually activated in residential areas. TJP can be thought of as a combination of two functions - Adaptive Cruise Control (ACC) and Lane Centring Assist (LCA). ACC, as the name suggests, is basically cruise control, which is adapted based on the speed of car in front. LCA is a function that aims to keep the car in the centre of the lane. The camera calculates the distance to the lanes and if the car approaches the edge of the lane, a small torque is introduced to the steering, in order to move the car close to the centre of the lane.

- Lane Keep Assist / Lane Departure Warning (LKA/LDW): Both LKA and LDW aim to keep the car within its lane. The difference between the two functions is that LDW emits a warning when the car is about to depart the lane, whereas LKA steers the car into the lane when it is about to leave the lane.

- Autonomous High Beam Low Beam (AHL): The AHL function autonomously switches the headlights from high beam to low beam and vice versa, to ensure that occupants of oncoming vehicles are not exposed to the glare of the headlights.

- Autonomous Dim Beam: The ADB function goes one step further - it dims portions of the headlights to ensure that all vehicles in the surroundings are not exposed to the glare of the headlights.

- Failsafe: The failsafe function is a set of checks which ensure that the Front Camera Functions go into a safe state in case of malfunctions. For example, camera hardware or software failure, fog, and smears on the camera, would cause the failsafe function to put the camera in a safe state.

3.3 EMC monitoring of Front Camera

A device that is electromagnetically compatible (EMC) with its environment should satisfy the following criteria [12] :

- Must not interfere with other devices
- Must not interfere with itself
- Must not be influenced by Electromagnetic emissions from other devices

The setup and tools used for EMC validation is outlined in the confidential report.

4 Problem Analysis

Chapter 1 outlined a very brief description of the problem at hand.This chapter contains details about the current solution, followed by details about the problem and its root cause.

4.1 Current tools

There are two versions of the EMC validation tool in use today. They are detailed in the confidential report.

4.1.1 Main Goals of The Project

Valeo will incur unnecessary costs if they continue to make new tools for every subsequent project. The main aim of the project is to make a tool that can be reused as far as possible.

Root Cause

The root cause was analysed and possible solutions were detailed. Please refer to the confidential report for more information.

Main Goals

- The new tool should ideally have the same functionality as the VW EMC software but should support all current and future projects.
- The tool should consist of alignment software and monitoring software.
- The monitoring software should be able to identify communication failures, and monitor DTCs and signals.
- If it is not possible to support all current and future projects:
  - The reason and alternatives should be explained, agreed upon and documented.
  - The tool should be easy to adapt for future projects or

- If it is proved that the tool cannot support all future projects, the tool should be created as a standard that can be followed for future tools.

5 System Requirements

This chapter outlines the approach to requirement analysis.

5.1 Requirements gathering process

The requirements were gathered by interviewing stakeholders. During stakeholder interviews, stakeholders were asked whether they had specific requirements that may be useful for the project. For EMC validation, a summary of what was required was provided. This summary was analysed and made into the final set of requirements. The requirements were analyzed based on guidelines from DYA Software [3]. The final set of requirements were obtained by mapping the initial requirements and refining them until they met the requirements guidelines. The following was checked for each requirement:

- Does the requirement fulfil a specific need
- Is the requirement verifiable
- Is the requirement realizable
- Is the requirement atomic
- Is the requirement traceable

Finally, the requirements were analyzed as a group in order to ensure the following:

- Requirements are free from contradictions
- Requirements are logically grouped
- Requirements sufficiently cover the domain

For tracking purposes, the requirements were also listed along with their owner,source, acceptance criteria, stakeholder, priority, rationale, type, and status.

For a complete list of requirements, please refer to the confidential report.

6 Conclusion

This chapter provides an overview of the results and compares it to the main aim of the project which was described in the introduction chapter. Further, recommendations and future work is briefly described.

6.1 Results

This project resulted in an easy to use EMC validation tool. All the high priority functional requirements were also met. The shared requirement sheet contains the status of the requirements.

The aim of this project was to ensure that the EMC tool can be reused across projects. Further, to reduce duplication of work in order to save time and money. There were two options in terms of direction:

- To create a tool which works for all EMC projects
- To create a tool that can be used as a standard, which can be easily adapted to work for future projects.

The first option proved to be impossible. Hence, the second option was considered. The new tool needs very little change to be adapted for a new project. This will reduce duplication of work and will save time and money for Valeo.

6.2 Future work and recommendations

This section describes recommendations and future work of the project.

- Follow the process section described in the appendix of the confidential report for future projects.
- Follow the adaptation guide in the confidential report when the tool is adapted to future projects.
- Explore the possibility to automate EMC testing. If the intensity of EMC interference can be controlled, the testing of an entire type of EMC interference can be automated.

- CANoe has a feature to generate test reports, which can be used to automatically generate test reports for the customer.
- Use Windows Forms to create a front end, which can communicate with CANoe and will not need to be imported for future projects.
- This tool was not made in accordance to the guidelines for software tools used in the automotive industry. Valeo must take into account the ASIL level of the component before using this tool to perform EMC validation.

7 Project Management

It is important to handle not only the technical aspects of the project, but also the non-technical aspects. This means managing the project well, creating a schedule, managing risks, reflecting regularly and adapting accordingly, and communicating effectively. This chapter briefly describes how the non-technical aspects described above was handled.

7.1 Project Planning

7.1.1 Project Schedule

The project was divided into two phases - the analysis phase and the design phase.

Figure 7.1 shows the schedule of the analysis phase, which consisted of the following tasks:

- Stakeholder Analysis
- Domain Analysis
- Problem Analysis
- Requirement Analysis
- Risk Analysis
- Use Case Analysis

Figure 7.2 shows the schedule of the design phase, which consisted of the following tasks:

- Architecture and Design
- Implementation
- Validation

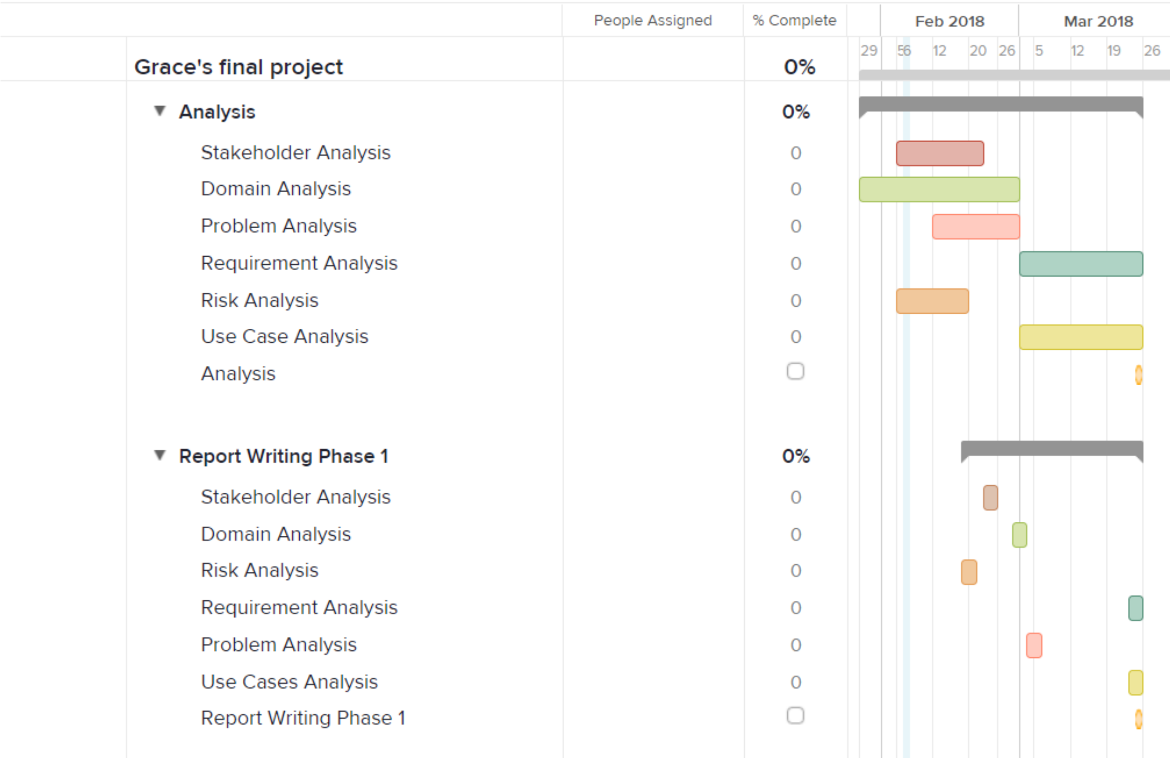

Figure 7.1: Project Management Phase 1

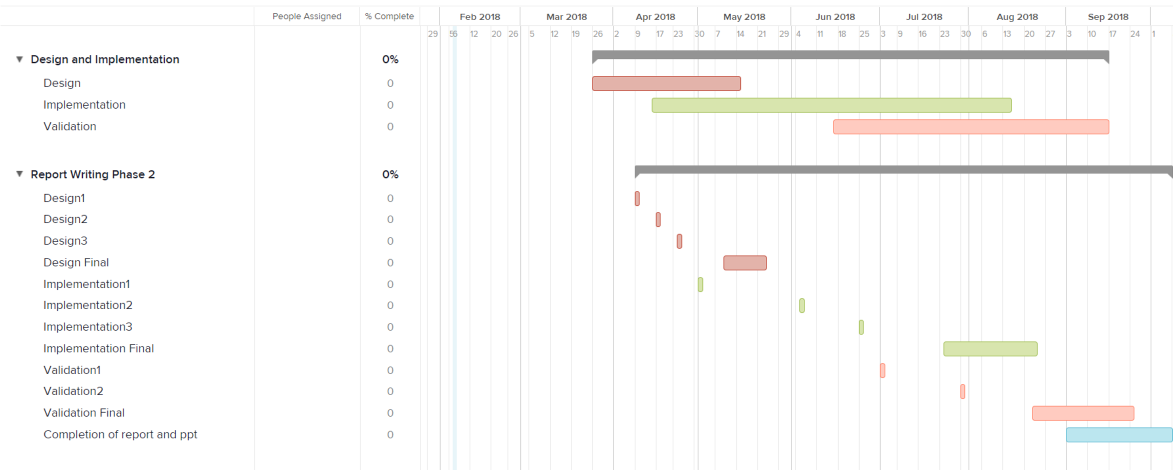

Figure 7.2: Project Management Phase 2

As expected, the plan that was created at the beginning had to be adapted based on risks and problems that were faced. Phase 1 was completed on schedule, although the individual tasks were reordered and expanded as necessary. Phase 2, on the other hand, was not carried out as planned due to unexpected delays. There was a total of two months delay due to delays in signing of the contract between the TU/e and Valeo and this lead to the visa not being issued in time. The updated schedule is shown in Figure 7.3.

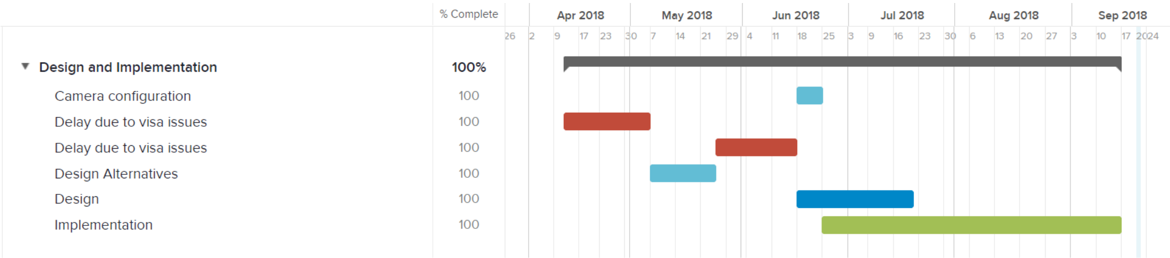

Figure 7.3: Project Management Phase 2

7.1.2 Project planning

The plan that was made at the beginning of the project was altered as necessary. Every Monday morning, a rough plan for the week was created. Every day, work done was logged as a diary entry. On Friday evenings, a retrospective was done which was used to decide the plan for the next week and update the project management strategy if required. Further, every Friday, a status report was sent to stakeholders. The report usually contained details of work done, blocking issues and a rough plan for the next week.

7.1.3 Communication

The following is the communication plan that was followed, apart from the status reports mentioned above.

- Project Steering Group (PSG) meetings were planned as recurring meetings as soon as the project started. During the PSG, progress and blocking issues were communicated.
- Weekly meetings on Monday morning were planned with the project mentor.
- Weekly meetings with the developers of the existing tool were planned during design and implementation.
- All other meetings with stakeholders were planned as and when needed.

7.1.4 Tools Used

The following tools were used for project management:

- One Note for diary entries, questions, tracking of to do lists, storing a log of status reports
- Teamgantt for planning the schedule of the project
- Google drive for sharing project deliverables - such as use cases, requirements, architecture, implementation etc. The deliverables were versioned from 0.1 to 1.0 and were updated based on feedback from stakeholders.
- Google sheets for planning sprints and tracking as well of sharing exact status.
- Status reports were sent out via email.

7.2 Risk Management

The project risks are summarized in Table 7.2

Table 7.1: Project Risks

Project Risks		
Description	Impact	Mitigation
All requirements will not be met	Unhappy stakeholders	Prioritize and group requirements. Send weekly and monthly status reports to stakeholders
Delay in signing contract between Tue and Valeo	Project was delayed by 4 weeks	Work a little longer during the first two months. Ask PDENG colleagues for advice for the stages that they have completed.
Delay in signing contract between Tue and Valeo	No access to confidential data	Reported this to stakeholders, who ensured access to documentation
Visa delays	Cannot work for more than 3 months in Germany with current visa	Travel back to The Netherlands and work on documentation. Communicate risks to stakeholders. Scope project if necessary. Apply for VPN access.
No documentation on the existing tool	Difficult to understand the tool and the issues that Valeo faces	Go through the source code; Schedule weekly meetings with developers of current tool
Slow response from stakeholders or experts	Impact on the project schedule, progress and quality	Speak to other experts or stakeholders Schedule meetings in advance Request project manager for alternatives Send reminders
Lack of training on CANoe and CAPL	Will affect the design and implementation	Ask current users of CANoe, CAPL for a demo. Use online documentation and tutorials. Obtain feedback continuously from developers.
The project scope is too broad	Project will not be completed in time	Report scope issues immediately. Scope project as required. Discuss with supervisors as soon as issues are identified

8 Project Retrospective

This chapter is a reflection report from the authors perspective.

8.1 Reflection

This project involved various technical and non-technical challenges. The non-technical challenges were much more challenging than the technical challenges. The most difficult problem was lack of time. The project had a total of two months of delays because Valeo and the TUe took time to sign off on the contracts. To make up for the lost time, the projects scope was reduced. In the 7 months that remained, there were further delays because testing equipment was not available during the implementation phase.

The main technical challenge was understanding how CANoe works. No CANoe training was available during the project. This challenge was overcome by reading documentation and talking to the EMC software development team every week.

The challenges were overcome because of continuous reflection and changes in strategy whenever required. The outcome of the project is a very effective tool that satisfies the non functional requirements.

Overall, I am very pleased that I was able to successfully design an elegant tool despite the challenges outlined above.

8.2 Quality Attributes

The quality attributes are revisited as a way of reflection.

Table 8.1: Quality Metrics

Quality Metrics	
Quality Attribute	**Metric**
Adaptability	• Number of cameras the tool supports -1 • Number of camera projects for which the tool can be adapted - Can be adapted to any project.
Agility	Number of interfaces the tool supports - Supports all interfaces via CANoe.
Configurability	• Number of signal parameters that can be configured - 10. • Number of tool parameters that can be configured -14. • Can log files be configured -yes. • Can the log file format be configured - yes.
Understandability	What percentage of users can understand the tool without training - not analysed
Usability	Is a comprehensive user guide included with the tool - yes.
Reuse	The number of components that are reused - The serial communication, panels, and system variables were reused.

Glossary

DTC	Diagnostic Trouble Code
OEM	Original Equipment Manufacturer
PDEng	Professional Doctorate in Engineering
DBC	Database File
PSG	Project Steering Group
TU/e	Eindhoven University of Technology
ECU	Engine Control Unit
CAN	Controller Area Network
ADTF	Automotive Data and Time-Triggered Framework

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