# Carolo-Cup 2015
# Lessons Learnt from static and dynamic disciplines

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# Contents


# 1. Introduction

The aim of this document is to give the reader an overview about the lessons learned in participating in the static and dynamic disciplines of the Carolo-Cup competition in 2015. This includes an evaluation of the presentation held (static), a benchmark of the competitors' performance (static and dynamic) as well as advices for future competitions. In detail, the paper will describe the agenda and organization of the presentation that was prepared for this years' competition. How was the information conducted? What is the reason for the design? Why did we decide on that specific structure? How much time was planned for each section? ...and many other questions should be answered after reading this document. In the other part of this paper, a systematic analysis of our competitors' performance is presented. Therefore we identify the most important features of their presentations, e.g. content, design, context, and bring them in line with their results in the dynamic disciplines. In other words, we try to analyze what we have to change/improve to perform better in future competitions.

The point distribution in Carolo-Cup is given in figure 1.1 for convenience. The exploded pieces show the static disciplines.

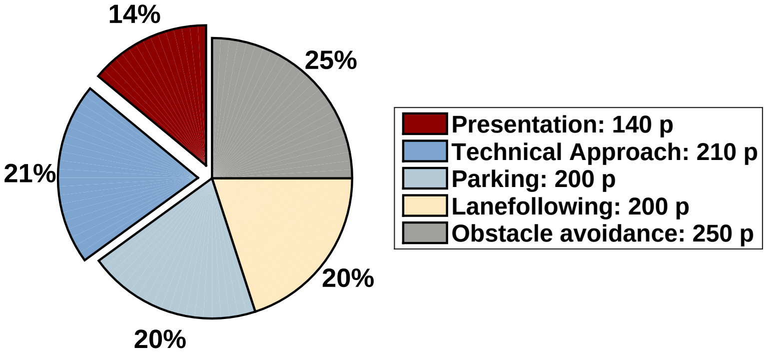


Figure 1.1: Point distribution in Carolo-Cup 2015


# 2. Presentation

The presentation or even called the *static discipline*, is the part of the competition where the teams have to present and defend their concepts and solutions in front of a jury. The jurors evaluate each team individually with a grade between 1 (maximum points) and 5 (0 points). The judges are experts from industry and research, and the jury usually consist out of 4-6 members. Each team has the possibility to outline the overall concept of their vehicle including hardware and software architecture. Furthermore, the Team Must describe how they managed energy-balance and manufacturing costs. Finally, they must explain their concept for the dynamic disciplines. The presentation has to address perception and control.

## 2.1 General comments

Team MOOSE received 275 out of 350 possible points in the static disciplines which resulted in the 9th position out of 17, see figure 2.1. The median value is 275 points which means that the result of Team MOOSE was clearly in the middle level.

The basis of this presentation was build upon the material from the 2014 Carolo-Cup Team. However, the final slides faintly reminiscent of the previous version. The main focus was put on corporate design, slide readability, data representation and the presentation outline. This was the result of extensive analysis of the previous years' top team's presentations and various rehearsals.

## 2.2 Organization

The presentation is organized in six sections, based on jury sheets from previous years:

1. Opening words and team introduction
2. Overall concept
3. Lane following
4. Parking
5. Obstacle avoidance
6. Test and verification

The first part (1), opening words and team introduction, is rather obligatory. It should not take longer than one minute and is very useful to start smoothly into the presentation. Additionally it

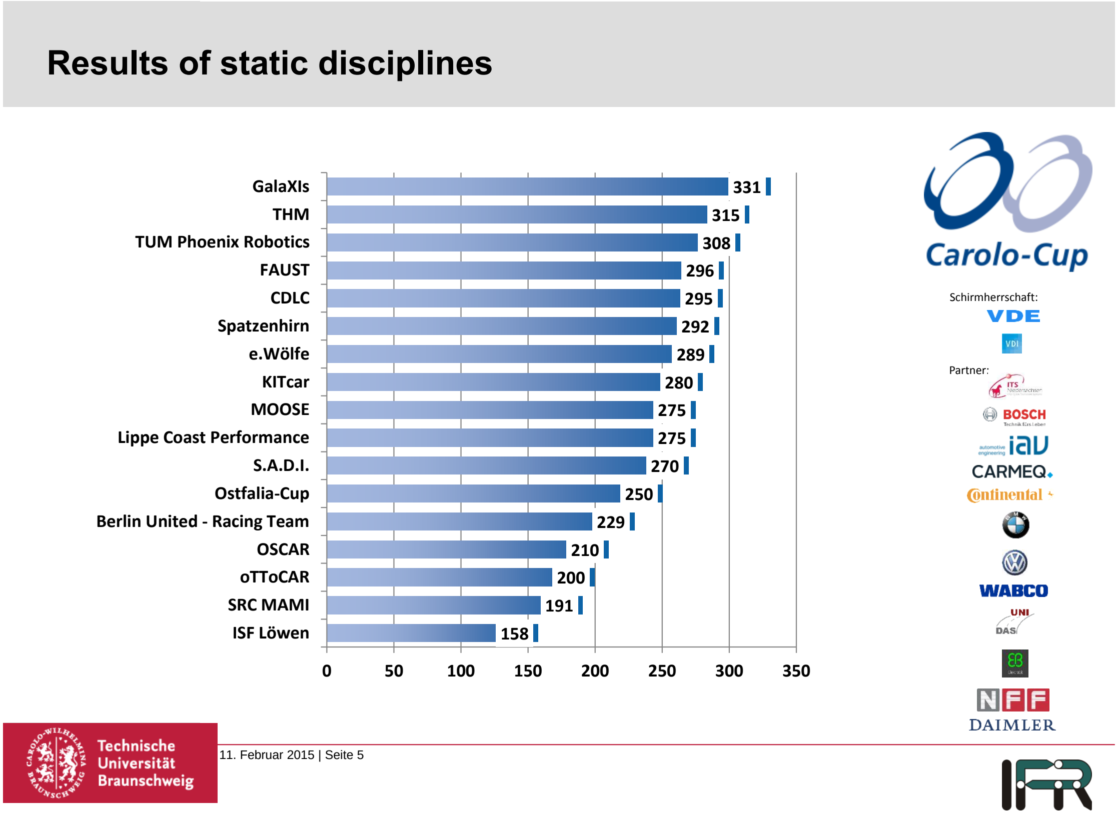


Figure 2.1: Results of static disciplines

allows the presenter to acclimate in the somewhat taut atmosphere and to gain some confidence for the imminent presentation.

In the second part (2) the main focus is directed towards hardware and software. But also sensor layout and chassis description are covered. One has to keep in mind that this part looks quite similar in most team's presentations. Thus, it is of high importance to put emphasis on features that separate our team from the others and highlight architecturally relevant parts of software and hardware.

The next part (3) of the presentation covers lane following. In more detail, we present our concept and process within the context of image processing. First the different components (lane-detector, driver, motor controller) are discussed, what leads us straight to the lane protection process. Here we describe how we process and analyse every frame captured by the camera, i.e. thresholding, rectangular fitting, classifications, filter, splitting and vanishing point calculation as well as the role of the PID controller.

Part four (4) presents parking. Here we basically describe how we made use of the sensors to ensure a smooth and error free parking sequence. Part five (5), obstacle avoidance, similarly talks about the use of sensory in combination with our lane detection algorithm. Whereas the parking could be implemented in the real car, the overtaking and stop line detection is mainly conceptional.

The last part (6), test and verification, introduces our test framework including test catalogue, binary classification and automated testing. We decided to put this towards the end, since it distinguishes from most of the other teams. Only cost and energy analysis are presented after that part, to sum up the presentation.

The presentation itself was held by one person. Hence, unnecessary switching back and forth between the presenters was not an issue. However, for the question and answer session one additional Team Member was sitting ready to answer deep technical questions.

## 2.3 Design

The design tries to follow a modern, clean and corporate look. Therefore the colors are oriented on a dark-red color scale, fonts are homogeneous, titles and subtitles have uniform sizes and information is presented consistently. The Powerpoint slides as well as the slide master file are avaiable in the repository. We recommend to establish a uniform look for presentation, homepage and other team related material.

## 2.4 Evaluation

In this section we evaluate the presentation. This is based on our own opinions and the feedback we got from the jury. Slides and content are evaluated first followed by the verbal part of the presentation.

### 2.4.1 Slides and Content

The design of the slides earned very good feedback. The unique and clean look was very appreciated. To make the design even better we suggest to work with animated content (e.g. gif-files or videos). Especially in order to show lane following/detection, it would revive the presentation immensely.

Apart from the design, content and structure of the presentation is obviously the most crucial part. It had been quite difficult to present all information within 20 minutes, but that also forced us to concentrate on only the important parts. As mentioned before, an introductory part in the beginning is compulsory and appreciated by the jury. It is important to keep this part as short as possible, to save time for the later sections. In our case this was solved well, although one jury member commented that we should have added an agenda in this part as well. The concept part, especially our software architecture and efficiency (energy, costs) received very good feedback from the jury. Despite that, it would have been an advantage to accentuate more on the interoperability of our hard- and software components. Additionally, it would have been profitable to bring both cars to the presentation room, to show the different chassis and features ‘live’ on our cars.

According to the feedback we got from the jury, lane following was well executed in perception and improvable in handling. In other words lane detection and image processing is acceptable but there is room for improvement when it comes to actually realizing it on with the car (frame rate, speed, latency). This should also give a hint on what parts next year’s team should focus on. However, there is definitely the capability of development in presenting this concept itself. The content was described on a very high level and therefore failed to persuade the jury members. It is recommended to start with a short description/overview of the lane following process, including the different components and algorithmic aspects, and then spotlight those features that protrude beyond other teams. On top of that a virtualization (e.g. a screencast) of the lane detection would help to polish this section vastly, as already mentioned above.

It's beyond us, how we received such an high score for our parking concept and control, considering that we could not even implement 'lane following' into our algorithms. But this shows how important an innovative and viable concept is, rather than the actual implementation. The other side of the coin, obstacle avoidance and stop line detection were not or only partly implemented. Concepts were poorly elaborated and lacked on innovative features. As a result these sections cost us most points. Here is definitely room for improvement, for the static but also dynamic disciplines. Our suggestion is to assign at least two Team Members to work on a concept for this problem. Even if it can't be implemented (e.g. due to a lack of resources), it can score a decent amount of points in the presentation. The last part on the other hand, test and verification, received very positive resonance and was scored accordingly. Especially the fact that we can run our test environment 'offline' and fast, received good feedback. The only thing to improve here would be to use the automated testing environment even more, to gain more test meters and a better tested algorithm. The jury feedback is summarized in table 2.1.

| Topic | Good | Bad | Suggestion |
|---|---|---|---|
| **Introduction** | short but informative | missing agenda | add agenda, fun facts to relax atmosphere |
| **Overall concept** (Test and Verification, Energy and Cost Analysis) | software architecture, modular car, virtual test framework, efficient resource consumption | alignment of SW and HW architecture | highlight unique parts, bring cars to presentation, more automated testing |
| **Lane following** | lane detection, image processing | realization, car handling | more emphasis on algorithmic/logical functions, add visualization of lane following algorithm |
| **Parking** | good ideas for concept | concepts not finished/realized, e.g. no lane detection implemented | develop a more confident concept, make smart use of the sensors |
| **Obstacle avoidance** | good ideas for concept | no proof of concept, vague concept | develop a more confident concept, make smart use of the sensors |

Table 2.1: Summary of jury feedback on MOOSE presentation

### 2.4.2 Presentation

The presentation itself was very calm and had a nice flow. For future presentation we would recommend a maximum of two speakers, because otherwise the flow might get a bit interrupted. One should also remember to use a little bit more gesture and enthusiasm to engage more excitement, than we did. It is often forgotten how persuasive and selling a good and enthusiastic talk can be. Finlay, we recommend to rehearse the presentation as often as possible, also in front of different audiences (e.g. teacher, friends, pet, parents etc.), to build the necessary confidence and routine for the final date. The official evaluation sheets from the jury are attached to this document, see Appendix A.2.

# 3. Benchmarking

This chapter reviews the performance of the other teams in the static and dynamic disciplines. The focus is put on how the top 5 teams which scored best in the static disciplines but the respective winners of the dynamic disciplines are reviewed as well. The purpose of this chapter is to figure out the (visible) differences between the MOOSE car, which results in recommendations for what to do next year in order to render higher scores. Lane following with obstacle avoidance is not included in the benchmark. This is due to the fact that the other disciplines clearly showed room for improvement. A result to anticipate from this section is the recommendation not to focus on obstacle avoidance as long as parking and lane following are not working highly reliable. A full list with links to YouTube videos from the benchmarked teams is given in appendix A.1.

## 3.1 Static disciplines

Recalling the results from the static disciplines shown in Figure 2.1, the main field of competitor ended up very close in score with Team MOOSE and were received a ranking in mediocrity. The results also show that there is only a weak correlation between static discipline result and overall result. Only the teams CDLC and TUM finished finally within the top 5 with having a top 5 score in the static discipline. The KITcar team is added to the benchmark list due to the fact that they ended up just one position ahead of Team MOOSE in the static disciplines but achieved the 3rd place in the overall result.

The overall top 5 teams in the static disciplines broadly use fast desktop processors (Intel i5) and large memory (>2 GB). The Phoenix team uses the Odroid XU3 which is about 18 % faster than the Odroid X2 used by Team MOOSE. The sensor setup of Team MOOSE is competitive in terms of sensor architecture. Other teams with similiar sensor setup are using sensor fusion algorithms. Localization and mapping methods (e.g. SLAM) were used only by the Spatzenhirn team.

| Overall Result | 2 | 8 | 5 | 12 |
|---|---|---|---|---|
| *Static* | 5 | 4 | 1 | 2 |
| *Parking* | -- | 6 | 3 | -- |
| *Lanefollowing* | 4 | 7 | 6 | -- |
| ***Team*** | CDLC | FAUST | Galaxis | THM |
| ***University*** | Braunschweig | Hamburg | Aachen | |
| *Camera* | IDS | µEye | 2d: Basler acA2040-25gc<br>3d: Asus Xtion | Playstation 3 Eye Cam @ 60 fps and 115 deg view angle |
| *Infrared* | Sensorcluster | | | |
| *Ultrasonic* | | | | |
| *IMU* | | | | MPU 6000 |
| *Wheelspeed* | | via motor | | via motor |
| *CPU* | fast than Intel Core Duo 1,66 Ghz | Intel i5 Haswell | Intel i5 1.3 Ghz | Intel i5 1.8 Ghz |
| *Memory / Storage* | 2 GB / unknown | 8 GB / 128 GB SSD | unknown | 4 GB Ram / 64 GB SSD |
| *Boards* | 3x 32 bit ARM µC | | Intel NUC<br>2x STM32F4 168 Mhz µC | Intel NUC<br>Tailor made<br>STM32F4 |
| ***Software*** | | | | |
| *Framework* | ADTF | Qt 5 | A number of different libaries are used | FreeRTOS |
| *Control* | unknown | unknown | Model predictive control for lateral dynamics | Model predictive control |
| ***Notes*** | | | | |
| | Insigths into Project management (slide 3) | Very inovative lane following algorithm | Computation times for algorithm (slide 26 - 28) | Online visualisation and recording of sensor data and parameter tuning (slide 5) |
| | CAN Bus | | Sepearate electric circuits for electronics and drive (slide 13) | Algorithms are shown also in "real world" and not only on theory (slide 16-24,26-42,43-51) |
| | Improoved points over last year shown (slide 11) | | Detailed information about hardware on slide 21 | |
| | Testing and debugging strategy: Unittests, Modultests, Systemtests and test coverage (slide 13) | | Algorithms are shown "in action" (slide 53+53,57-65) | |
| | Screenshots and algorithm level explanation of concepts | | 3d Camera for parking spot detection | |
| | clever IR dead zone handling (slide 8) | | 4 WD and all two steering axis | |
| ***Alternatives to concepts shown and discusses*** | | | Discussion PID vs MPC: Gainschduling-PID more complex, curvature for feedforward needed... | |

| | | | |
|---|---|---|---|
| 4 | 1 | 3 | *11* |
| 3 | 6 | 8 | *9* |
| -- | 2 | 7 | *--* |
| 2 | 1 | 2 | *10* |
| **TUM** | **Spatzenhirn** | **KITcar** | ***MOOSE*** |
| **Munich** | **Ulm** | **Karlsruhe** | ***Chalmers*** |
| Playstation Eye 2 Cam | 2d: 656 x 490 px, max 160 fps, 3d: Asus Xtion | | *µEye UI-1221LE-M-GL 752x480, wide angle lens* |
| | | | |
| | | | |
| | | | |
| via motor, hollow shaft | | | |
| Odroid XU3<br>4x 2 GHz ARM | CPU: Intel i7, 4 x 2.5 GHz; GPU: nVidia Quadro K600 | Intel i5 | *Odroid U2<br>4x 1.7 GHz ARM* |
| 2GB / unknown | unknown | unknown | *2 GB / 8 GB eMMC* |
| Odroid XU3 (Camera)<br>Atmega32U4<br>Atmega644P (Sensors and actuators)<br>Atmega8 (remote control) | Asus PBH67 and tailormade boards for acutators, sensors and HMI | NUC and Arduino | *Odroid U2 (Camera, main operating board)<br>2x Arduino Mega (assigned to senor and actuator)* |
| | | | |
| Tailormade (Phoenix) | ADTF | ROS,protobuf, OpenCV | *OpenDaVINCI* |
| unknown | unknown | Stanley approach | *PID* |
| | | | |
| Offline Software Debugging with error reproduction and analysis of failures (slide 17) | Supplementary light scanner | Line laser | *light sensor for adaptive threshold* |
| Sensorfusion (camera, ultrasonic, infrared) for obstacle detection | Localization and mapping | | |
| Parking boxed detection with camera | Image processing on GPU | | |
| | 1D Gridmap for parking (slide 39) with light scanner and 3d camera | | |
| | | | |
| | | | |
| | Alternative chassis concept (slide 18), unsprung mass, robustness vs additional functions (esp, torque vectoring), stability and lower center of gravity | | |

## 3.2 Parking

As shown in the results, only 8 out of 17 teams received points in the parking discipline. The average duration for parking was (without taking the penalties into consideration) 11.7 s and the average penalty was 12.5 s (only the best out of two runs was taken into account). The videos show that in fact only the SADI team delivered an error free complete parking with magnificent performance (6.69 s, no penalty). An important implementation detail is however the fact that their car starts literally immediately to move when one presses the according button on the backside of their car. As the overall time renders in the total score of the discipline, next year's team should definitely aim for to keep all latencies (e.g. from the buttons) as low as possible. Only the Spatzenhirn and the SADI team did not get any penalties. Their algorithms are shown on a high level in their presentation and they differ from other approaches (e.g. Team MOOSE approach) in the way that the steering angle is not kept constant while driving backwards. That means, unlike the Team MOOSE approach, they do not bound the trajectory in order to *force* tracking two circular trajectories. With their impressive parking they've achived 6th overall place having been beaten by Team MOOSE in the static discipline and lane following. This result stresses the recommendation for the next year's team to improve the parking algorithm.

Team MOOSE failed to deliver a successful parking. As seen on the video the reason for this is the fact that the implemented algorithm can not compensate for limited straight running ability and depends to a large extend on the initial orientation of the car and also on the current battery level.

## 3.3 Lane-following

The result from the lane-following discipline is given in Appendix A.4 and are summarized as follows: The teams traveled 62 m in average but this is in consideration of the penalties which resulted in having negative distance traveled for some teams. Considering only those teams which ended up in a distance larger than zero, the average is 123.7 m. All teams received an average penalty of 86 m. Considering only teams with a overall positive result, the average penalty is 85.6 m. Team MOOSE traveled 64 m and received 40 m penalty. While the low speed naturally resulted in the below average result, the lane following itself was fairly robust (compared to other teams) and reliable as the punishment was clearly below average. From the result slides (see appendix A.4) it is obvious that even an error free lane following algorithm (no penalties) would have let to an improvement to rank 7 which clearly shows that there is a need for higher speed in order to achieve higher scores. From a mechanical perspective the other teams (and in particular the top 5 teams) differ from the MOOSE car in terms of very high running straight ability, smooth steering control and high dynamics. The former is a clear issue of the combination of the heavy car weight and the chassis used having rather large backlashes and noticeable clearances.

# 4. Recommendations and suggestions

In the last section of this report, we draw a conclusion from the previous sections and summarize them in a number of recommendations and suggestions for the next year's team.

## 4.1 Car and hardware

As mentioned before, more emphasis should be spent on a robust and reliable parking algorithm. As shown, this year only a very small number of competitors managed to park the car successfully. Therefore vehicle dynamics theory must be taken into account as this will bring a lot of opportunities to improve parking.

The need for increasing speed was discussed and motivated above. The MOOSE car was one of the slowest cars on the pitch. There is no other way to render more points in the lane following discipline than cruising with higher speed. It can be assumed that the other teams, and especially those who received high penalties will also spend time and effort on their lane following algorithm. Once these *high-speed* cars work reliable, they which will push the MOOSE car down to lower scores.

A remark about the lane-following algorithm: Rather than looking for a goal line at each sampling time, emphasis should be spent on combining the current and previous goal lines into splines in a way that the resulting trajectory is smooth and the next goal line is predicted and corrected when the measurement arrives. Starting from this, a compensation for missing lanes is a far more easy task as the obtained knowledge about each road segment can be used, e.g. robustness to missing lanes in curves as the slow varying curvature is known from the previous curve segments.

Mechanical improvements: The MOOSE car has poor straight running ability and motor dynamics. The vehicle movement is unsmooth and inert compared to the top 5 teams studied (see YouTube videos).

A proper data logging framework needs to be implemented. This allows to understand the behaviour or misbehaviour of algorithms based on the recorded data. Finally, this would also enraptures the jury.

## 4.2 Team and Team Management

Other teams stick usually together for a longer period of time (12 - 18 months). In order to deliver a competitive car, the available time should be used very efficiently. An example for this could be to mimic the Chalmers Formula Student team approach. They use a proven overall framework, consisting of a prestudy face, design face and testing. This could be adapted for the Carolo-Cup project. It is very important to build up a basic knowledge about the competition,software (OpenDaVINCI) and basis challenges within the first weeks. After that, the teams should split into different subgroups. Each one dives in deeply into the car, the rules, software, hardware, etc. from their subgroup's perspective. After approximately 4 weeks, the subgroups present their results and communicate their findings with the rest of the team. For example, the people responsible for parking have studied different possible solutions and defined requirements (e.g. sensor setup) during that time. This means they can motivate and discuss the need for a resolution higher than 0.5 cm for IR sensor when they are used for aligning the car. A project manager, whose main task is to keep track of all the work synchronization between the subgroups but also strengths links between the subgroups, needs to be appointed.

The MOOSE team had a terrible lack of sophisticating communication between the members which resulted in a long *open task* list which no one really cared about as everyone has rather his own *to-do* list in his head and does not communicate properly to all Team Members involved what one is doing right now. Team MOOSE failed to bring all (interested) Team Members on an equal level of knowledge. Only a few Team Members have been able to start the car, i.e. know the startup procedure (super-component, proxy, driver). The supervision of the next year's team should really focus on distributing the knowledge within the team, e.g. by arranging coaching sessions or workshops. Team MOOSE was a comparably huge team. However, the rolls and tasks of the team members haven't been clearly defined which resulted both in an unbalanced distribution of workload between the team members and also very different learning outcomes for every student in the team. In order to improve the mentioned points it is proposed to make objective agreements on what topic they will work on with the students right at the beginning of the project. This could also serve as basis for the individual assessment.

We also propose to organize this project course with a professional system development approach, e.g. the V-Model or run agile methods like SCRUM. This would teach professional skills and gives a clear benefit for students. The responsibility of maintaining the chosen approach lies within the supervisors and the project management.

The next year's team should consist of students from different fields. Other teams and in particular the top 5 teams usually have a balanced mix of electronics, mechatronics, mechanical engineers and computer science students. By having a rather large team where the students usually have a number of different background and nationalities, arranging one or two students from the International Project Management Master's programme programme should be taken into consideration. This would also give the Carolo-Cup course the opportunity for being attractive for students outside the engineering and computer science programmes.

## 4.3 Conclusion

This report summarizes the lessons learnt from contributing in the 2015 Carolo-Cup and should serve as incremental step toward a further improvement of the Chalmers Teams contribution in the next year's competition. The jury feedback is evaluated and linked to specific parts of the presentation. Clear suggestions for future contestants are given. For the benchmarking the teams' presentations given in this year's competition to present technical approaches and solution strategies have been analyzed and compared to Team MOOSE. Furthermore, we discussed the lessons learned from this year as gathered in the authors perspective and from discussion within the team after the competition. Our main findings are that the presentation was satisfying and the sources of deduction of points are analyzed. Thus, by applying the suggestions given in this report a team can improve certain aspects of their presentation for the next year's competition.

Furthermore, improvement of reliability of the parking algorithm is stressed as well as the need for a higher cruising speed for the lane-following discipline. Due to the complexity of the used software in terms of algorithms it is considered to be crucial to integrate the whole team into the development. The interdisciplinary character of this project serves as unique opportunity to get hands on with the development and implementation of the development of highly automated vehicles.

To the authors knowledge this document is the first in-deep analysis of the results from a Chalmers Carolo-Cup team from the student's perspective. A technical evaluation of the Carolo-Cup competition itself was done by Zug et. al. in 2014[1]. The authors recommend to use that work as supplementation to the hardware benchmarking done in this work as this work gives an overview about the hardware architecture used in this year's competition.

[1] Zug et.al. *Technical Evaluation of the Carolo-Cup 2014 – A Competition for Self-Driving Miniature Cars* Presented at ROSE: Proceedings of the 12th IEEE International Symposium on Robotic and Sensors Environments Online available: http://www.cse.chalmers.se/ olafl/papers/2014-10-rose-zug-carolo.pdf

# A. Appendix

## A.1 Links to YouTube Videos

The following table contains links to the YouTube videos. Last availability check: May 27, 2015

| | Parking | Lane following | Obstacle avoidance | Position |
|---|---|---|---|---|
| **Spatzenhirn** | http://youtu.be/vNzvnUAdoho | http://youtu.be/7X87_44r0mI | http://youtu.be/o_IR-KdHnlg | 1 |
| **CDLC** | http://youtu.be/-7T-nod0rbY | http://youtu.be/66u8cMorKTg | http://youtu.be/iuGiSrWjDfI | 2 |
| **KITcar** | http://youtu.be/w3N_xhtU-K8 | http://youtu.be/0uaAIErgDpc | http://youtu.be/BCPFBJpiRx4 | 3 |
| **Phoenix** | – | http://youtu.be/NtG7mqH9qIY | http://youtu.be/tBHK3vXTdLA | 4 |
| **GalaXis** | http://youtu.be/QJpphFSrR3w | http://youtu.be/A0jrUImZra8 | http://youtu.be/RIMrRC01a_M | 5 |
| **S.A.D.I.** | http://youtu.be/vLCvfePdI7o | – | – | 6 |
| **FAUST** | http://youtu.be/azYagxk0x1M | http://youtu.be/oMj7Ov9xFSw | – | 8 |
| **THM** | – | http://youtu.be/al1vKX2bprA | – | 12 |
| **MOOSE** | http://youtu.be/_2V695Wfqik | http://youtu.be/EsjNVwqMeSs | – | 11 |

Table A.1: YouTube videos from the competition

## A.2 Jury feedback on presentation

Technische Universität Braunschweig

Carolo-Cup

**Statische Disziplinen 2015 – Feedback-Bogen**

**Team: MOOSE** [redacted]

**Juror:** ______________

| | Kommentar |
|---|---|
| Vortrag | Agenda fehlt<br>+ Teamvorstellung am Anfang |
| Konzept<br>Systemübersicht | + modulares HW-Konzept<br>+ durchdachtes SW-Konzept/Architektur inkl. Validation<br>+ offline Testen mit logged data, automated testing<br>warum nicht mehr als 500m |
| Fahren auf der Straße | |
| Einparken | ~~no show~~ – no lane following during parking (risk) |
| Hindernisse<br>Kreuzungen | no show in challenge (crossings with obstacle) overtaking |

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Technische Universität Braunschweig

Carolo-Cup

## Statische Disziplinen 2015 – Feedback-Bogen

**Team: MOOSE**

**Juror:** [redacted]

| | Kommentar |
|---|---|
| Vortrag | Team ✓ |
| Konzept Systemübersicht | Sehr gute Übersicht |
| Fahren auf der Straße | ✓ |
| Einparken | Empirische ohne lane detection |
| Hindernisse Kreuzungen | ✓ |

Technische Universität Braunschweig

Carolo-Cup

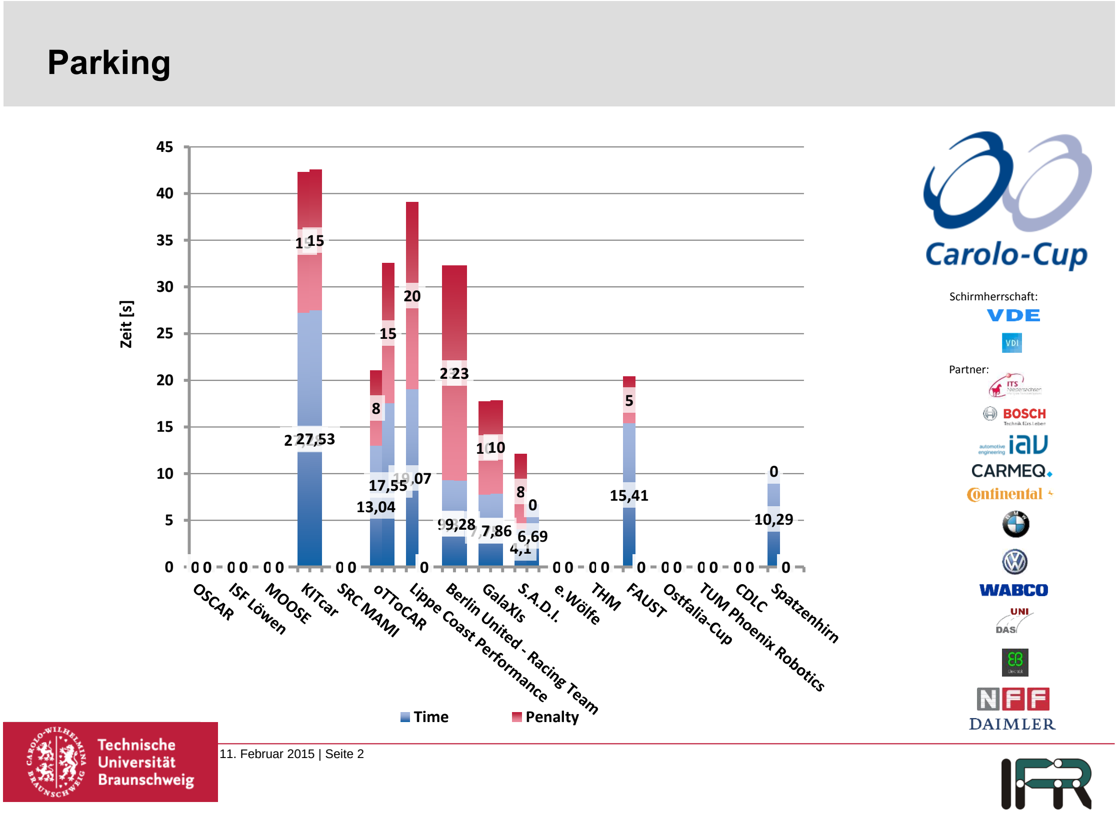
**Statische Disziplinen 2015 – Feedback-Bogen**

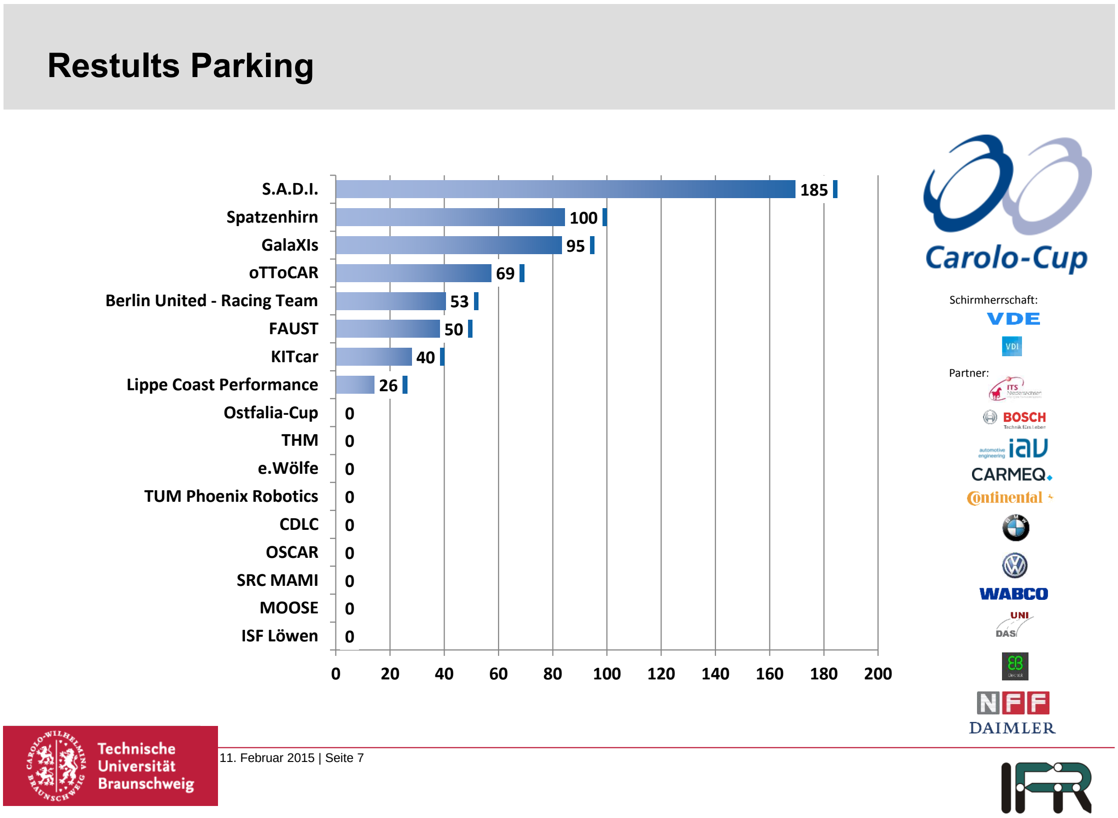
**Team:** ~~ISE Löwen~~ MOOSE

**Juror:** [redacted]

| | Kommentar |
|---|---|
| Vortrag | · very clear and good presentation |
| Konzept Systemübersicht | · efficient ressource consumption ++<br>· very smart virtual test framework (SIL)++<br>· smart idee „modular car" |
| Fahren auf der Straße | |
| Einparken | · several concepts need should be finished -> potential for next year (lane detection) |
| Hindernisse Kreuzungen | · good concepts, unfortunatly not completely finished |

## A.3 Result slides: Parking



## A.4 Result slides: Lane following