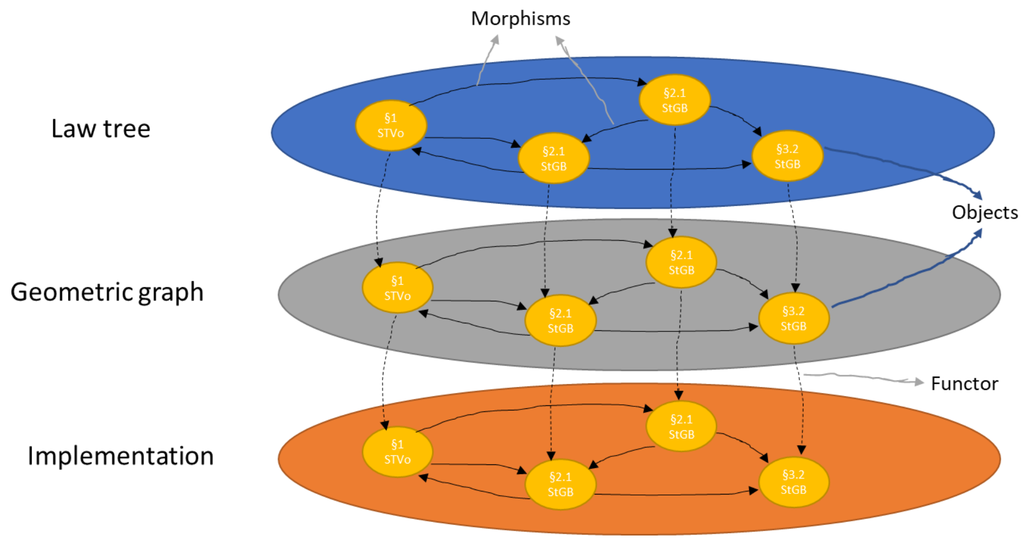
Topic	Applied Compositional Thinking for Autonomous Vehicles
Background	In many domains of engineering, it is beneficial to **deal with abstraction and compositionality explicitly**, to improve both the understanding of problems and the design of solutions. A kind of mathematics particularly well-suited for **thinking about compositionality is applied category theory**. However, outside of computer engineering, only little algebra is taught, in favor of analysis and related fields. Kontrol has developed a technology which allows to convert written traffic rules into its digital equivalent (software) by interpreting the rules geometrically. The digital rules are processed in real time in a rule engine which certifies that a generated trajectory is safe and compliant to the traffic rules. Certification means that the correctness of the developed system can be proven mathematically. **To date this is not possible for autonomous systems.**
Goal	Applied category theory has the potential to close this gap. The goal of this work is to investigate how the applied category theory can be applied to solve the certification problem of autonomous vehicles. The idea is to define different categories representing the different domains (law, geometrics, system theory, and software engineering) involved in the certification process of autonomous systems and define the mappings inside (morphisms) and between (functor) the categories. Furthermore, it should be investigated which mathematical concepts and methods can be applied to prove the correctness of the translation process from the law tree down to the implementation. This work is highly experimental.  The image above shows an example of categories which could be used to describe the transformation of written rules (like the Austrian traffic act – Straßenverkehrsordnung) and associated laws like the Strafgesetzbuch, Kraftfahrgesetz to its geometric interpretation category and to it is implementation category as software on an ECU of the car. Each of the three colored discs (blue, grey, and orange) form one category. Inside each disc there are objects (yellow circles) where each represents e. g. the paragraphs of the laws (StVO, KFG, …) and the black arrows, called morphisms, are the mapping between the objects (paragraphs). Mapping objects and morphisms from one category to another category (e. g. paragraph of the category law tree to its equivalent in the category Geometric graph) is called functor. A functor is the mapping of a written paragraph object of the law tree category to its equivalent object in the geometric graph category using geometric and/or probabilistic interpretation. It is the final goal of the

	project to embed the already existing manual conversion process into the mathematical frame work of the category theory to ensure that minimize the amount of errors which can happen during the development.
Prerequisites	Openness to explore the foundation of a newly developed theory. Work on real world problem with a new mathematical approach Thinking abstract Theory 50%, Implementation 50 %
Direct Supervisor	Michael NADERHIRN