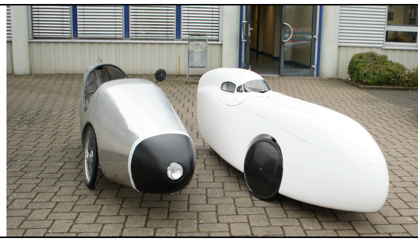	**Stella** **: Control** **: Evolution Strategies**

Title	*Stella: Control: Evolution Strategies*
Context	**BRSU: Internal project on efficient transportation**
Module	R&D and Master Thesis
Semester	2-4
First Advisor	Prof. Dr. Alexander Asteroth Tel. 02241-865 290, E-Mail: alexander.asteroth@h-brs.de
Second Advisor	N.N.
Language	English
Credits	15 / 25
Prerequisites	Basic knowledge of autonomous mobile robotics and machine learning techniques, interest or background in EE/hardware, interest in efficient transportation, good C/C++ programming skills, good grades in 1. semester
Project objectives	Stella is a project on light electric vehicles (LEV). It addresses efficiency issues as well as hybridization strategies. For electrically power assisted cycles (EPAC) or electrically power assisted velomobiles (EPAV) the driving strategy shall be optimized and controlled by the vehicle. Given start and goal coordinates, the route and control strategy is to be planned in a way that a given objective is optimized. The objective might be as simple as to minimize the energy needed to travel the route at a given speed, but can also include the drivers physical abilities and needs. The resulting strategy then serves as a basis for semi-autonomous driving. This RnD addresses the control strategy. The target to be minimized will be the energy needed to travel a given route in limited time (a subsequent Master Thesis might address the more general problem of hybridization). Optimal solutions can be found by optimal control theory only under certain conditions. In the general case the state-space can be discretised and searched by heuristic search like A*. It turns out that the space needed to find a good approximation to the optimal solution in this way is extremely large (350 TB for a 30km tour). The approximation of the strategy found by complete search by Evolution-Strategies (ES) seems promising. First results using genetic

	algorithms proved the applicability. In this RnD further studies using more general ES shall be carried out.
List of deliverables	Minimum • Comprehensive literature research of current research in this area (annotated bibliography) • Working implementation of ES solving control problem Expected • Comprehensive analysis of ES in comparison to complete search and optimal control theory solution • Route specific as well as more general control strategies Maximum • Parallel Implementation of above (GPU/BRSU parallel computing platform) • Evaluation of strategy on real vehicle
Management Plan	• Biweekly project meetings • Meetings with Prof. Asteroth from time to time • Presentations after 1. 3 month 2. 6 month 3. before colloquium
Milestones	• Proficient knowledge of ES and it's application (literature research) • Project Proposal • Working implementation • R&D report
Learning target	Proficient knowledge of ES and their application in autonomous mobile robotics.
Starting Literature	[1] J. Santin, C. Onder, et al.: The Worlds most Fuel Efficient Vehicle – Design and Development of PAC Car II, VDF Verlag, ETH Zürich, 2007 [2] H.-G. Beyer, H.-P. Schwefel: Evolution Strategies – A comprehensive introduction, Natural Computing 1, pp. 3-52, Kluwer Academic Publishers, 2002 [3] Sciarretta A., Guzzella L., van Baalen J., "Fuel Optimal Trajectories of a Fuel Cell Vehicle,", Proceedings of AVCS 2004 [4] Sundström O., Ambühl D., Guzzella L. "On Implementation of Dynamic Programming for Optimal Control Problems with Final State Constraints," 2010, Oil & Gas Science and Technology – Rev. IFP, Vol. 65 (2010), No. 1, pp. 91-102 [5] Grossoleil, David, and Dominique Meizel. "PRACTICAL DESIGN OF MINIMAL ENERGY CONTROLS FOR AN ELECTRIC BICYCLE." 9th International Conference on Modeling, Optimization & SIMulation. 2012.