Shared and cooperative control of ground and air vehicles
Introduction and general overview

Flemisch, Frank; Canpolat, Yigiterkut; Altendorf, Eugen; Weßel, Gina; Baltzer, Marcel; Abbink, David; Itoh, Makoto; Pacaux-Lemoine, Marie Pierre; Schutte, Paul

DOI
10.1109/SMC.2017.8122717

Publication date
2017

Document Version
Final published version

Published in
Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics (SMC 2017)

2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC)
Banff Center, Banff, Canada, October 5-8, 2017

Shared and cooperative control of ground and air vehicles: Introduction and General overview

Frank Flemisch, Yigiterkut Canpolat, Eugen Altendorf, Gina Weßel
Institute of Industrial Engineering and Ergonomics
RWTH Aachen University
Aachen, Germany
{ f.flemisch; e.altendorf; y.canpolat; g.wessel} @iaw.rwth-aachen.de

Frank Flemisch, Marcel Baltzer,
Fraunhofer FKIE
Wachtberg, Germany
{ frank.flemisch; marcel.baltzer}@fkie.fraunhofer.de

David Abbink
Faculty of 3mE
Delft University of Technology
Delft, The Netherlands
d.a.abbink@tudelft.nl

Makoto Itoh
University of Tsukuba
Tsukuba, Ibaraki 305-8573 JAPAN
itoh.makoto.ge@u.tsukuba.ac.jp

Marie-Pierre Pacaux-Lemoine
Laboratoire d'Automatique et de Mécanique Industrielles et Humaines
Université de Valenciennes et du Hainaut Cambrésis
Valenciennes, France
marie-pierre.lemoine@univ-valenciennes.fr

Paul Schutte
Aviation Development Directorate
AMRDEC / RDECOM, US Army
Brooklyn, NY, USA
paul.c.schutte2.civ@mail.mil

***Abstract*— Emerging technologies in the field of automatization meanwhile enable partially and highly automated vehicles in the aviation and automotive domains, where the human operators are assisted or (partially/temporarily) replaced in their tasks by advanced automation systems. Nevertheless due to technological limitations and ethical reasons, full autonomous vehicles in both domains might not be realizable in the near future. Instead system designs, which enable shared and cooperative guidance and control of vehicles by human operators and automation systems could be more feasible solutions.**

This paper sketches a common framework of shared and cooperative control that describes the two concepts not as different but as coinciding concepts for the shared intentionality, control and cooperation between humans and machines. A brief overview off developed shared and cooperative control designs in the aviation and ground vehicle domain is given.

Keywords*— *human machine systems, human machine cooperation, joint action, shared control insert

I. WHY DO WE NEED MODELS OF HUMAN MACHINE ISSUES?

Thinking about human machine systems and automation starts with good models and methods to design and evaluate those systems and to ensure their safety, efficiency and joy of use. Human and organizational factors have to be more taken into account at the early stage of the design, and focus on these human aspects are now highlighted in the national and international calls. In France for example, the Ministry of Ecology, Sustainable Development and Energy drew up an inventory of the technological accidents that occurred in 2014 [1]. The study mentions that technological accidents are primarily caused by material failures (37%) and human errors (63%). Regarding human errors, it highlights that "it is essential to understand the organizational context that results in these primary causes". We think that the understanding of cooperation and the sharing of tasks, between humans, but also between humans and machines, are essential for improving that situation and to build better human machine systems.

II. INTRODUCTION: FROM SHARED AND COOPERATIVE CONTROL OF SITUATIONS TO SHARED AND COOPERATIVE CONTROL BETWEEN HUMANS AND MACHINES

One of the outstanding abilities of homo sapiens is the ability to cooperate in complex situations with other members of its genus and also with other species [2]. Although other species have this ability to a certain degree, their capability of cooperativeness is limited to unsophisticated situations [3] According to [4] the ability to cooperate for reaching common goals, was one of the main reasons for the fast development of homo sapiens to the most dominant species on earth, which highlights that shared and cooperative control of situations has been influencing the development of homo sapiens much longer than human-machine systems exist.

Furthermore, the development of tools affected the human society, where the created tools became more and more complex over the centuries. This process enabled humans, first to extend their physical power and mobility and afterwards their cognitive capability, as tools with cognitive features were created, which were able to act automatically in limited situations. Due to the latter technological progress, the automated tools (machines) could either support the human in fulfilling his/her tasks or take over the main task, substituting the human.

Nevertheless, cooperation between the human and the automated machine is required in order to benefit from both partners' strengths. [5] structured the complexity of possible human-machine cooperation and interaction designs by introducing the concept of levels of automation. This concept describes a model for the variety of possible task divisions between human and machine while acting on the same task simultaneously. Moreover, the concept of cooperation in the context of human-machine systems was investigated by e.g. [6], [7] and [8].

In detail, cooperativeness in human machine systems represents the accordance of the machine's and the human's acting, emphasizing that the design of the machine should be supplemental to the needs of the human [9]. This requires a certain degree of interaction between the human and automation for e.g. arbitration in cases of conflicts. Furthermore, the goals and skills of the partners have to be assessable and understandable for each other [10]. This can be achieved by supplemental detection of the environment and consistent depiction of information and action. Furthermore, a major aspect is that the partners share a common perception of the current situation, because cooperation without a similar understanding of the present and without the same prediction of the future situation might not be possible [11], [12], [13], [14].

Another model for cooperation in terms of safety critical situations, was introduced by [15], [16], [17] which defines know-how (to operate) and know-how–to-cooperate via a common work space as a model of cooperation. The agent's ability to control the process is defined as the know-how(to operate). Know-how-to-cooperate is the capability of the agent to cooperate with other agents, who are involved in the control of the process, whereby the know-how-to-cooperate is partitioned in an external and internal part. The external part is the agent's ability to provide information to other agents and to get information from those. The internal part of the know-how-to-cooperate is the agent's capability to synthesize a model of other agents

A concept, which is similar to cooperativeness, is the concept of shared control. Shared control includes any kind of operational action, which has a direct impact on the mutual task of the partners. For example, the longitudinal dynamics of a vehicle can be controlled jointly by the human driver and the automation, whereby the partners are interacting with each other via haptic interfaces (e.g. gas/brake pedal) [18].

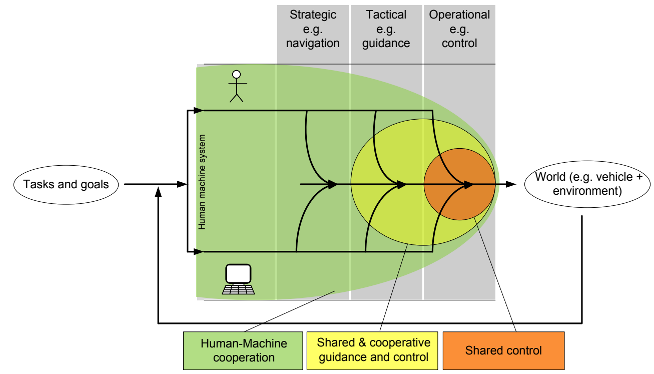

Figure 1. Proposed relationship between the Shared control, shared and cooperative Guidance and control, human-machine cooperation [18]

In Figure 1 the task is divided into operational, tactical and strategic level. On these levels, cooperation between human and automation can take place. As indicated by the inner area outlined in Figure 1, tasks included in shared control are focused on the operational level [19], [20].

Nevertheless, both concepts, cooperative and shared control interleave. [18] describe shared control as the "sharp end" of human-machine cooperation on the control level, where cooperation can happen on the "blunt end" on guidance or navigational level as well, without explicit shared control. Figure 2 illustrates this relationship by using an example from everyday life. Two persons carrying a table are sharing control of the table as they both directly influence it's movements. Furthermore they share the guidance or maneuvering of the table by moving it around e.g. obstacles. Also the navigation is shared by the partners as they move the table to a certain destination in the room. If one of the humans is replaced by e.g. a robot, this example would illustrate shared and cooperative guidance and control for a human-machine-system, since the cooperation between the partners is happening on all three levels. In case that only the movements of the table are influenced and controlled by the partners, whereas a third entity commands guidance and navigation, the interaction between the carrying partners can be considered as shared control due to the limited cooperation on the operational level. The interaction between the third entity and the carrying partners can be described as shared and cooperative guidance and control or as human-machine (human-human) cooperation, where cooperation happens on tactical and strategical levels [18]. Additional definitions of joint, shared or cooperative control are described by e.g. [21].

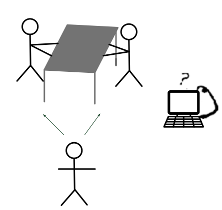

Figure 2. Everyday situation with joint action, shared control and human-human cooperation [18]

Meanwhile the human society is confronted with an increasingly high number of automated machines, whereby the cooperative and shared control between humans and machines, became a major aspect for using the advantages of automation technology. For the air/ground vehicle domains this interaction concept was introduced by, e.g. [22], [23]; [24], [25], [26].

III. SHARED AND COOPERATIVE GUIDANCE AND CONTROL IN AIR VEHICLES

In the aviation domain, the development towards highly automated and intelligent aircraft resulted in advantages as a. reduction of the (physical) workload. Nonetheless several problems like, mode confusion or human-out-of-the-loop occurred while using advanced assistant and automation systems in aircrafts [27], [28].

[23] introduced the H-Metaphor as an interaction-concept for pilots to reduce these problems in highly automated aircraft. The H-Mode is derived from the H-Metaphor, which is a design metaphor comparable to the desktop metaphor for PCs. It describes that the human and an automated system are interacting on different levels of assistance and automation, whereas this interaction is comparable to the interaction between a rider and a well trained horse. Like the horse that can be guided and controlled by loose or tight rein, the vehicle can act in some circumstances autonomously, but allows the operator to take back control at any point. The implementation of the H-mode for aircraft, H-Mode 3D allows to control the full range of guidance and control automation systems via a single consistent interface system and interaction scheme [29]; [30]. This also involves sophisticated maneuvers as takeoffs, landings, and automated conflict/hazard avoidance.

Operators can choose between Loose Rein, where the avionic system(s) has a high degree of autonomy, and Tight Rein, where the operator has the control on the steerage. In Tight Rein the automation supports the pilot only limitedly unless it predicts emerging conflicts and danger for the aircraft. In case of predicted danger the automation communicates this information to the pilot by visual and haptic interface devices. In Loose Rein-mode the pilot controls the transitions between maneuvers, thus remains in-the-loop while the automation achieves the control tasks. Figure 3 shows a potential H-inspired flight control system

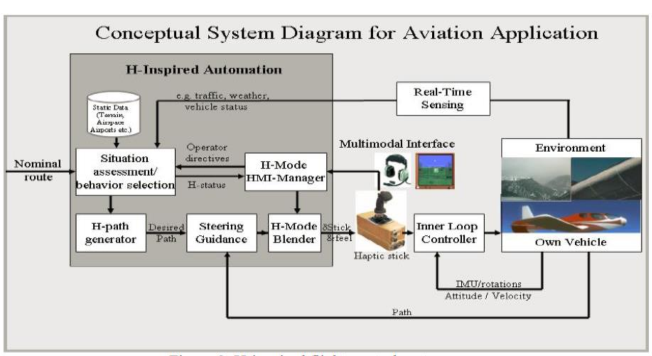

Figure 3. H-inspired flight control system [31]

The H-mode concept is also a part of the Naturalistic flight deck concept, which was introduced by [31]. This concept uses a complementary automation design where both partners have complementary capabilities.

The pilot is involved in tasks and decisions with significant consequences on the overall mission and safety and is less involved in operations, which are relatively deterministic and require precision in time-critical situations. The tasks and their supporting interfaces are divided in two partitions, Actual and Notional system, in order to avoid mode confusion and to support situation awareness.

The pilot uses the Actual system to get tactical information e.g. safety of flight and to control all operations that "cause physical or external responses by the aircraft or its systems" [31]. The Notional System includes information and tasks for longer-range decision making such as flight planning and in-flight strategic decision making. The design of the Actual system is based on the H-mode, whereas the Notional system is based on the metaphor of an electrical assistant such as a flight dispatcher.

[32] applied the shared control concept for the teleoperation of unmanned aerial vehicles (UAV). Since there is a lack of sensory information in teleoperations, the guidance of UAVs via the control inceptor might be confusing. On the other hand additional information is provided to the operators using visual modalities, which can cause an overload of the visual channel. Haptic feedback has the potential to unload the visual channel and can compensate the lack of other modalities by communicating potential collisions. Therefore the automation creates an artificial force field, which maps environmental constraints. The haptic feedback increases proportional to the artificial force field if the operator guides the UAV to a potential collision zone. The operator shares the control of the UAV with the automation using this kind of haptic coupling, for collision avoidance.

Extension of shared and cooperative control between pilot and auto-pilot has also been proposed in fighting aircraft towards a reinforcement of cooperative decision making between a pilot and a weapon system officer who share the same environment, but also between a pilot and an AWACS officer who is in a different environment [33].

IV. SHARED AND COOPERATIVE GUIDANCE AND CONTROL IN GROUND VEHICLES

An analogical development to the aviation domain, shared control and cooperative assistance and automation is emerging in the ground vehicle domain lately e.g., [34], [35], [30]. Since a cooperative human-machine system can have various configurations, in terms of e.g. responsibility, authority and capability of the partners, standard categorizations of vehicle automatization were created [36], [37]. These standards were mainly derived from the thought that assistance and automation can be placed on the same scale or spectrum of control distribution, at first described by [23].This assistance and automation scale was influenced by the long discussed levels of automation [5], [38], [8], [39], [40], that led to the definition of assisted, partially, highly and fully automated vehicles.

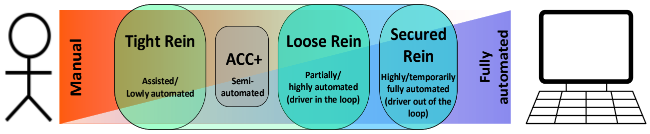

Figure 4. Levels of assistance and automation with H-mode automation levels [42]

As described in chapter 2, the H-Mode can be seen as a specific implementation of shared and cooperative guidance and control, which was introduced in the ground vehicle domain subsequently [41].

Applied to this domain, H-Mode enables the haptic-multimodal interaction and execution of the driving task by the human and the automation [42]. It includes complex technical functions in a way that enables three different modes, which can be switched intuitively for assisted, partially and highly automated vehicle guidance and control [43].

Figure 4 illustrates the simplified distribution of control between the driver and the automation by a scale of assistance and automation. By choosing the “Tight Rein” mode, the human driver is assisted while driving the vehicle. Furthermore, suggestions via haptic signals on the control device are communicated to the driver. In the “Loose Reign” mode, partially automated driving is conducted, where the automation takes the lead of the vehicle control and the human is coupled by a haptic interface to the automation and vehicle for initializing driving maneuvers. In the “Secured Reign”-mode (highly automated driving) the automation temporarily has full control over the vehicle, whereas the driver has to observe the traffic situation. Other implementations of partially and highly automated driving in the truck domain focus on platooning and highly automated truck convoys, e.g. [44], [45].

Another implementation of shared and cooperative guidance and control in the vehicle domain is the concept of conduct-by-wire (CbW). Within this concept, a maneuver-based guidance and control of highly automated vehicles is realized [46], [47].The implemented human-machine-interface enables the selection of possible maneuvers for the human driver, whereas the control of the vehicle’s longitudinal and lateral dynamics is conducted by an automation system. Moreover, the driver can enter mission parameters and select route data.

In the CbW approach, the division of the driving task between the human driver and the automation is realized by a static and hierarchical role distribution. An additional fallback mode is realized for system boundaries, where the driver has to take over the control of the vehicle’s dynamics.

In contrast to CbW, an interaction concept based on shared control was introduced by [20], [48], [49] and [50]. As described in the first section the cooperation between the partners in shared control takes place on the operational level and is realized by haptic interaction between partners. In the vehicle domain this includes the control of lateral and longitudinal vehicle dynamics as well as haptic interfaces like steering wheel and gas/brake pedal to manipulate the vehicle’s dynamics. Thus [20] introduced a gas pedal with haptic feedback, where the automation adapts the haptic properties e.g. stiffness of the pedal according to the traffic situation and neuromuscular responses of the driver. This flexibility enables faster and more precise manipulation of the vehicle’s speed. Additionally, the concept of a steering wheel with haptic feedback and adaptation was introduced by [51]. This should support the driver controlling the vehicle’s lateral dynamics, comparable to the above mentioned pedal concept. The stiffness of the steering wheel is adapted and steering torques are added by the automation in order to successfully achieve the required driving manoeuvers. [52] showed that haptic guidance is helpful to maintain performance of steering maneuver for fatigued drivers.

Recently, Saito and Raksincharoensak have proposed a detailed design of haptic feedback on a steering wheel [53], [54]. Based on the fact that expert drivers can perceive many more structural details and potential hazards in driving environment and quickly adapt to changing environments, the developed assistance system activates risk-predictive braking control for the slowing down task to increase his/her safety margins at a location including a blind area. Thus, the slowing down task at the tactical and the operational levels is shared between the human and the assistance system, and the human driver is guided to “a referenced speed" through a haptic gas-pedal interface [54] or a brake-intervention manner [53]; the assistance system can cope with the potential risk arising due to a pedestrian who initiates a road crossing from the driver’s blind area.

In order to realize effective shared and cooperative control, it is a vital issue to evaluate cooperative status between human and automation in the haptic shared control. Nishimura et al. [55] introduced a definition of “cooperative status” from the viewpoints of the intent consistency between human and the automation and initiative-holder and it was applied to the adaptive gain-tuning method of the haptic shared control, which achieved smooth transition from lane keeping assist manual lane-changing. The haptic shared control and the gain-tuning method have been applied to the shared authority mode connecting the automated driving to manual driving for smooth authority transfer by gradual changes of control strength and by encouraging the driver to engage in the control [56], [57].

Another concept using a steering wheel with haptic feedback for shared control was introduced by [58], [59]. The developed assistant system for forward obstacle avoidance, intervenes into the lateral control of the vehicle by adding steering torque, which amplifies the steering torque of the driver. If the driver doesn’t react in appropriate time, the assistant system intervenes also into the longitudinal dynamics of the vehicle by conducting an emergency brake. Nevertheless if the time to collision is critical and the driver doesn’t steer the vehicle, the assistant system may turn the steering wheel by itself to avoid the collision. Thus, in less critical situations the assistant system and the human driver share the lateral control of the vehicle in order to avoid a collision but in high critical situations the assistant system has the autonomy to manipulate the vehicle's dynamics by braking and steering.

In shared and cooperative control, improving human skill is also a vital issue because a guidance system may fail. [60] demonstrated that the haptic shared control has an effect of improving driver's skill as well as reducing his/her workload with its guidance with the example of backward parking of an automobile.

In railway domain, and especially for tram system, haptic control is a useful way to support cooperation between tram-driver and controller for eco-driving [61]. Eco-driving command takes into account tram and tram-driver models, as well as their interaction in order to optimize motion, energy consumption and driver acceptability.

V. OUTLOOK: TOWARDS A UNIVERSAL LANGUAGE FOR SHARED AND COOPERATIVE GUIDANCE AND CONTROL OF MOVEMENT

With the emerging field of uninhabited air & ground Systems, UAS/UGS, the domains of air and ground vehicles are coming much closer together, with operators switching back and forth between different vehicles and domains more often. One of the longer reaching dreams with cooperative guidance and control is to have a common language to cooperate on movement, independent from the numbers of controlled dimension. This multimodal language could not only applied to cars and airplanes, but also to UAV's, UAS, robots, spaceships etc., everything that moves and is cooperatively controlled by a human and an automation. But before a standardization, the design spaces of cooperative guidance and control should be explored not only with single breakthrough implementations, but also with systematic explorations and mapping of the design space.

ACKNOWLEDGMENT

The conducted research was partly funded by the Deutsche Forschungsgemeinschaft (DFG) within the projects "Arbitration of cooperative movement for highly-automated human machine systems" and "Systemergonomics for cooperative interacting vehicles". Another part of this research was funded by the National Research Council and NASA Langley, by the EU and DLR in the EU-Projects HAVEit and InteractIVe, by JSPS KAKENHI 17H00842 and by the VIDI project 14127, which is (partly) financed by the Netherlands Organisation for Scientific Research (NWO)

REFERENCES

[1] Blanc, P., Normand, A., Robert, C., Gauthier, A., Michel, J. -F., Pitrat, Robache, A. (2015). Inventaire 2015 des accidents technologiques. Ministère de l'Écologie, du Développement durable et de l'Énergie, Direction générale de la prévention des risques.

[2] Sebanz, Natalie, Harold Bekkering, and Günther Knoblich. "Joint action: bodies and minds moving together." Trends in cognitive sciences 10.2 (2006): 70-76.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] Harcourt, Alexander H., and Frans BM De Waal. Coalitions and alliances in humans and other animals. Oxford University Press, 1992.

[4] Tomasello, Michael. A natural history of human thinking. Harvard University Press, 2014.

[5] Sheridan, T. B., and W. Verplank. "Human and Computer Control of Undersea Teleoperators. Cambridge, MA: Man-Machine Systems Laboratory, Department of Mechanical Engineering." MIT (1978).

[6] Rasmussen, Jens. "Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models." IEEE transactions on systems, man, and cybernetics 3 (1983): 257-266..

[7] Hollnagel, Erik, and David D. Woods. "Cognitive systems engineering: New wine in new bottles." International Journal of Man-Machine Studies 18.6 (1983): 583-600.

[8] Sheridan, Thomas B. Humans and automation: System design and research issues. John Wiley & Sons, Inc., 2002.

[9] Bubb, Heiner. "Ergonomie." 3. Aufl., Kap. 5.3 Systemergonomische Gestaltung, S. 390–420). München: Carl Hanser Verlag (1993).

[10] Flemisch, F, Winner, H, Bruder, R & Bengler, K.2014. Kooperative Führung von teil- und hochautomatisierten Fahrzeugen; Hrsg. Winner et al. Handbuch Fahrerassistenzsysteme; Springer.

[11] Endsley, Mica R. "Toward a theory of situation awareness in dynamic systems." Human Factors: The Journal of the Human Factors and Ergonomics Society 37.1 (1995): 32-64.

[12] Salas, Eduardo, et al. "Situation awareness in team performance: Implications for measurement and training." Human factors 37.1 (1995): 123-136.

[13] Stewart, R, Harris, D, Houghton, RJ, Baber, C, McMaster, R., Salmon, PM, Hoyle, G, Walker, GH, Young, MS, Linsell, M, Dymott, R & Green, D 2006. Distributed situation awareness in dynamic systems: theoretical development and application of an ergonomic methodology. Ergonomics, 49, 1288-131l.

[14] Shu, Yufei, and Kazuo Furuta. "An inference method of team situation awareness based on mutual awareness." Cognition, Technology & Work 7.4 (2005): 272-287.

[15] Lemoine, M. P., et al. "Cooperation between humans and machines: first results of an experiment with a multi-level cooperative organisation in air traffic control." Computer Supported Cooperative Work (CSCW) 5.2 (1996): 299-321.

[16] Hoc, Jean-Michel, and Marie-Pierre Lemoine. "Cognitive evaluation of human-human and human-machine cooperation modes in air traffic control." The International Journal of Aviation Psychology 8.1 (1998): 1-32.

[17] Pacaux-Lemoine M & Debernard, S 2002. A Common Work Space to support the Air Traffic Control. Control Engineering Practice, A Journal of IFAC, 10 (5), pp. 571-576.

[18] Flemisch, Frank, et al. "Shared control is the sharp end of cooperation: Towards a common framework of joint action, shared control and human machine cooperation." IFAC-PapersOnLine 49.19 (2016): 72-77.

[19] Michon, John A. "A critical view of driver behavior models: what do we know, what should we do?." Human behavior and traffic safety. Springer US, 1985. 485-524.

[20] Abbink, David A. "Neuromuscular analysis of haptic gas pedal feedback during car following." Behaviour 65.10 (2006): 1.

[21] Mulder, Mark, David A. Abbink, and Erwin R. Boer. "Sharing control with haptics seamless driver support from manual to automatic control." Human Factors: The Journal of the Human Factors and Ergonomics Society 54.5 (2012): 786-798.

[22] Hoc, Jean-Michel. "From human–machine interaction to human–machine cooperation." Ergonomics 43.7 (2000): 833-843.

[23] Flemisch, F. O., Adams, C. A., Conway, S. R., Goodrich, K. H., Palmer, M. T., & Schutte, P. C. (2003). The H-Metaphor as a guideline for vehicle automation and interaction.

[24] Flemisch, F., Kelsch, J., Löper, C., Schieben, A., Schindler, J., & Heesen, M. (2008). Cooperative control and active interfaces for vehicle assitsance and automation.

[25] Biester, L 2008 Cooperative Automation in Automobiles. Diss., Humboldt-Universität zu Berlin.

[26] Holzmann, Frédéric. Adaptive cooperation between driver and assistant system: improving road safety. Springer Science & Business Media, 2007.

[27] Billings, C. E. (1997). Aviation automation: The search for a human-centered approach.

[28] Wiener, Earl L. "Human factors of advanced technology (glass cockpit) transport aircraft." (1989).

[29] Goodrich, K. H., Schutte, P. C., Flemisch, F. O., & Williams, R. A. (2006, October). Application of the H-mode, a design and interaction concept for highly automated vehicles, to aircraft. In 25th Digital Avionics Systems Conference, 2006 IEEE/AIAA (pp. 1-13). IEEE.

[30] Goodrich, Kenneth, Ralph Williams, and Paul Schutte. "Piloted evaluation of the H-mode, a variable autonomy control system, in motion-based simulation." AIAA Atmospheric Flight Mechanics Conference and Exhibit. 2008.

[31] Schutte, P. C., Goodrich, K. H., Cox, D. E., Jackson, B., Palmer, M. T., Pope, A. T., ... & Kinney, J. B. (2007). The naturalistic flight deck system: An integrated system concept for improved single-pilot operations.

[32] Lam, T. M., Boschloo, H. W., Mulder, M., & Van Paassen, M. M. (2009). Artificial force field for haptic feedback in UAV teleoperation. IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans, 39(6), 1316-1330.

[33] Millot P., Pacaux-lemoine M. (2013). A common Work Space for a mutual enrichment of Human-machine Cooperation and Team-Situation Awareness. 12th IFAC/IFIP/IFORS/IEA Symposium on Analysis, Design, and Evaluation of Human-Machine Systems, Las Vegas, Nevada, USA, août

[34] Flemisch, Frank Ole, and Reiner Onken. "The cognitive assistant system and its contribution to effective man/machine interaction." The Application of Information Technology (Computer Science) in Mission Systems (1998).

[35] Schutte, Paul. "Complemation: An alternative to automation." Journal of Information Technology Impact 1.3 (1999): 113-118.

[36] Gasser, T. M., & Westhoff, D. (2012, July). BASt-study: Definitions of automation and legal issues in Germany. In Proceedings of the 2012 Road Vehicle Automation Workshop.ISO 690

[37] On-road Automated Vehicle Standards Committee. SAE J3016: Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems. SAE International.

[38] Sheridan, Thomas B. Telerobotics, automation, and human supervisory control. MIT press, 1992.

[39] Sheridan, Thomas B. "Adaptive automation, level of automation, allocation authority, supervisory control, and adaptive control: distinctions and modes of adaptation." IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans 41.4 (2011): 662-667.

[40] Parasuraman, Raja, Thomas B. Sheridan, and Christopher D. Wickens. "A model for types and levels of human interaction with automation." IEEE Transactions on systems, man, and cybernetics-Part A: Systems and Humans 30.3 (2000): 286-297.

[41] Flemisch, F. O., Kelsch, J., Schieben, A., & Schindler, J. (2006). Stücke des Puzzles hochautomatisiertes Fahren: H-Metapher und H-Mode, Zwischenbericht 2006.

[42] Altendorf, E.; Baltzer, M.; Heesen, M.; Kienle, M.; Weissgerber, T. & Flemisch, F. 2016. "H-Mode 2D - A Haptic-Multimodal Interaction Concept for Cooperative Guidance and Control of Partially and Highly Automated Vehicles" Winner, H.; Hakuli, S.; Lotz, F. & Singer, C. *(Eds.)*: *Handbook of Driver Assistance Systems,* Wiesbaden: Springer.

[43] Flemisch, F., Meier, S., Baltzer, M., Altendorf, E., Heesen, M., Griesche, S., ... & Damböck, D. (2012). Fortschrittliches Anzeige-und Interaktionssystem für die kooperative Führung hochautomatisierter Fahrzeuge: Ausgewählte Ergebnisse mit H-Mode 2D 1.0.

[44] Hjälmdahl, M.; Krupenia, S. & Thorslund, B. 2017. "Driver behaviour and driver experience of partial and fully automated truck platooning – a simulator study" European Transport Research Review, 9 (8): 1-11.

[45] Baltzer, M. C. A.; Rudolph, C.; López, D. & Flemisch, F. 2017. "Cooperative Guidance and Control in Highly Automated Convoys - StrAsRob" Road and Rail - Vehicle Automation, Stanton, N. A.; Landry, S.; Bucchianico, G. D. & Vallicelli, A. (Ed.): Advances in Human Aspects of Transportation, 547-560. Switzerland: Springer

[46] Winner, H., & Hakuli, S. (2006, October). Conduct-by-wire–following a new paradigm for driving into the future. In Proceedings of FISITA World Automotive Congress (Vol. 22, p. 27).

[47] Geyer, S., Hakuli, S., Winner, H., Franz, B., & Kauer, M. (2011, June). Development of a cooperative system behavior for a highly automated vehicle guidance concept based on the Conduct-by-Wire principle. In Intelligent Vehicles Symposium (IV), 2011 IEEE (pp. 411-416). IEEE.

[48] Abbink, D. A., and M. Mulder. "Exploring the dimensions of haptic feedback support in manual control." Journal of Computing and Information Science in Engineering 9.1 (2009): 011006.

[49] Abbink, David A., and Mark Mulder. Neuromuscular analysis as a guideline in designing shared control. Rijeka, Croatia: InTech, 2010.

[50] Mulder, Mark, David A. Abbink, and Erwin R. Boer. "Sharing control with haptics seamless driver support from manual to automatic control." Human Factors: The Journal of the Human Factors and Ergonomics Society 54.5 (2012): 786-798.

[51] Mulder, M., Abbink, D. A., & Boer, E. R. (2008, October). The effect of haptic guidance on curve negotiation behavior of young, experienced drivers. In Systems, Man and Cybernetics, 2008. SMC 2008. IEEE International Conference on (pp. 804-809). IEEE.

[52] Wang, Z., Zhen, R., Kaizuka, T., Shimono, K., Nakano, K. (2017). The Effect of a Haptic Guidance Steering System on Fatigue-Related Driver Behavior, IEEE Transactions on Human-Machine Systems, Vol. PP, Issue 99, 8 pages.

[53] Saito, Y., Raksincharoensak, P. (2016). Shared Control in Risk Predictive Braking Maneuver for Preventing Collisions with Pedestrians, IEEE Transactions on Intelligent Vehicles, vol.1, no.4, pp. 314-324

[54] Saito, Y., Raksincharoensak, P. (2017). Risk Predictive Haptic Guidance: Driver Assistance with One Pedal Speed Control Interface, In Systems, Man, and Cybernetics (SMC), 2017 IEEE International Conference on (to appear).

[55] R. Nishimura, T. Wada, and S. Sugiyama, “Haptic Shared Control in Steering Operation Based on Cooperative Status Between a Driver and a Driver Assistance System,” J. Human-Robot Interact., vol. 4, no. 3, pp. 19–37, 2015.

[56] T. Wada and R. Kondo, “Shared Authority Mode: Connecting Automated and Manual Driving for Smooth Authority Transfer,” in Proceedings of Future Active Safety Technology toward Zero Traffic Accidents, 2017.

[57] T. Wada, K. Sonoda, T. Okasaka, and T. Saito, “Authority Transfer Method from Automated to Manual Driving via Haptic Shared Control,” in Proceedings of IEEE International Conference on System, Man, and Cybernetics, 2016.

[58] Itoh, Makoto, Tatsuya Horikome, and Toshiyuki Inagaki. "Effectiveness and driver acceptance of a semi-autonomous forward obstacle collision avoidance system." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. Vol. 54. No. 24. Sage CA: Los Angeles, CA: SAGE Publications, 2010.

[59] Itoh, M., Inagaki, T., & Tanaka, H. (2012, October). Haptic steering direction guidance for pedestrian-vehicle collision avoidance. In Systems, Man, and Cybernetics (SMC), 2012 IEEE International Conference on (pp. 3327-3332). IEEE.

[60] S. Tada, K. Sonoda, and T. Wada, “Simultaneous Achievement of Workload Reduction and Skill Enhancement in Backward Parking by Haptic Guidance,” IEEE Trans. Intell. Veh., vol. 1, no. 4, pp. 292–301, Dec. 2016.

[61] La Delfa S., Enjalbert, S., Polet P., Vanderhaegen, F. (2016). Eco-driving command for tram-driver system. IFAC Analysis, Design and Evaluation of Human-Machine Systems, Kyoto, Japan, août .