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INTERACTIVE STEERING WHEEL FOR OPTIMAL OPERATION

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INTERACTIVE STEERING WHEEL FOR OPTIMAL OPERATION

The only part that maintains a consistent direct tactile contact to the driver as well as performing a driving task that is the steering wheel. It is thus an essential part of the human-machine interface in the automobile. But the complexity of its operating elements has increased rapidly over the past few years due to assistance systems. Takata and Audio Mobil Elektronik developed an interactive communication steering wheel with ergonomic switches, a monitor with touch functions and a hands-on recording. Thus, sensory overload can be reduced and operation can be optimised.

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COMMUNICATION FUNCTIONS AT THE STEERING WHEEL

The steering wheel is a vehicle component with a history of more than hundred years. While the first years of developing steering wheels were dominated by moderate development stages, the last 20 years have dynamically introduced electronic components in the steering wheel. The steering wheel as an interface between the driver and the vehicle is increasingly used for communication purposes. The communication functions at the steering wheel can be classified as follows: There are warning functions, control functions, sensor functions and comfort functions, ❶.

A warning function at the steering wheel is the vibration motor, for example. Hazardous situations recorded by the vehicle (like a lane departure) are transmitted to the driver via vibrations at the steering wheel. The multi-function switch is an example of an operating function at the steering wheel. This multi-function switch enables the driver to control various buttons at the steering wheel to activate different functions [1, 2].

The steering wheel as a communication interface between the driver and the vehicle is also useful for sensing. "Hands on Wheel" (HOW) uses a capacitive sensor at the steering wheel rim. Such a sensing function passes information to the vehicle (to the system adaptive cruise control, ACC [1]) concerning whether the driver has one or both hands on the wheel, or no hands at all in the case of traffic jams. Heating is a classic comfort function at the steering wheel.

COMMUNICATION IN THE COCKPIT TODAY

The market offers steering wheels with up to 24 switches, and it has become apparent that the number of interfaces has also exponentially increased in cockpit and centre console. The driver's environment has drastically changed over the past 30 years and has distinctly increased the requirements on the driver, ❷.

The high number of features, functions and components of networking takes the driver to his cognitive limit when it comes to processing information. This hypothesis was evaluated in a series of empirical human-machine interface examinations by the National Highway Traffic Safety Administration – US Department of Transportation (NHTSA). Here, controversial results are achieved. The NHTSA presumed a distraction of a visual, manual, and cognitive kind, by putting the acoustic distraction to one side. Amongst other things, the time was measured in which the driver takes his eyes off the road to carry out a task. The individual period of a glance should not exceed 2 s, the cumulative overall distraction time was of 12 s [3].

Over a period of three years, nine vehicles were tested in another study, from the compact to the upper middle class of well-known car manufacturers [4]. The results are remarkable: for entering a navigation destination, an average time of between 80 and 175 s (NHTSA target: 24 s) is required for the task – depending on the OEM. For this task, the eyes were fixed on the screen for between 46 and 78 s (NHTSA target: 12 s). The NHTSA's recommendations are exceeded several times over today in the current vehicles.

❶ The four communication functions at the steering wheel

In the meantime, many different institutions [5, 6] have addressed this subject of "distraction while driving". It is proved how dangerous networking components actually are in vehicles.

Due to the developments of the past years, vehicles of the current generation become increasingly more complex and thus strongly influence the driver's attention. As the studies show, future challenges that reflect the developments of networked vehicles can no longer be met with conventional operating systems.

Every seat in the car requires or enables another operating scenario. The driver's primary task is therefore to drive the car and only limited capacities remain available to "search" for buttons or displays.

INTERACTIVE STEERING WHEEL FOR SOLUTION

With regard to the subject of distraction, one solution could be the iCS by Takata and Audio Mobil Elektronik. This stands for "Interactive Communication Steering Wheel". This innovative concept of an interactive steering wheel combines all necessary input possibilities in the steering wheel as interface, without having to take the hands off the wheel or to look across the dashboard searchingly. Whether it is information about speed, kilometres driven or the tank level, engine speed, average velocity, navigation, radio or air conditioning menues, everything is integrated into the steering wheel and can be operated in the quickest way possible, just like the indicator button, headlight control, windscreen wipers or other known functions.

In a joint cooperation between both companies, the iCS steering wheel was created as a result of research and development with regard to human-machine interface in the context of modern vehicles. One of the main targets of the iCS development was to concentrate information and operation optimally within the driver's view and reach, that is, at the steering wheel.

Smartphones operated alongside or additionally to the car's own systems represent a major safety risk. Their functionalities and user interfaces are, however, very popular. It would therefore be of advantage to transfer these two factors to the steering wheel and to adapt them to automotive technology.

Across five years, the prototypes 1 to 3 were tested by Audio Mobil in a simulator with different displays and switch/button combinations in various arrangements [7]. Together with the Car-Lab (Christian-Doppler Laboratory for Contextual Interfaces) at the University of Salzburg, test persons carried out numerous test drives, which resulted in the set-up of the first iCS system at the beginning of 2013. The sum of the results from the development of the three pre-stages and the pattern formed the basis for developing the driveable iCS prototype.

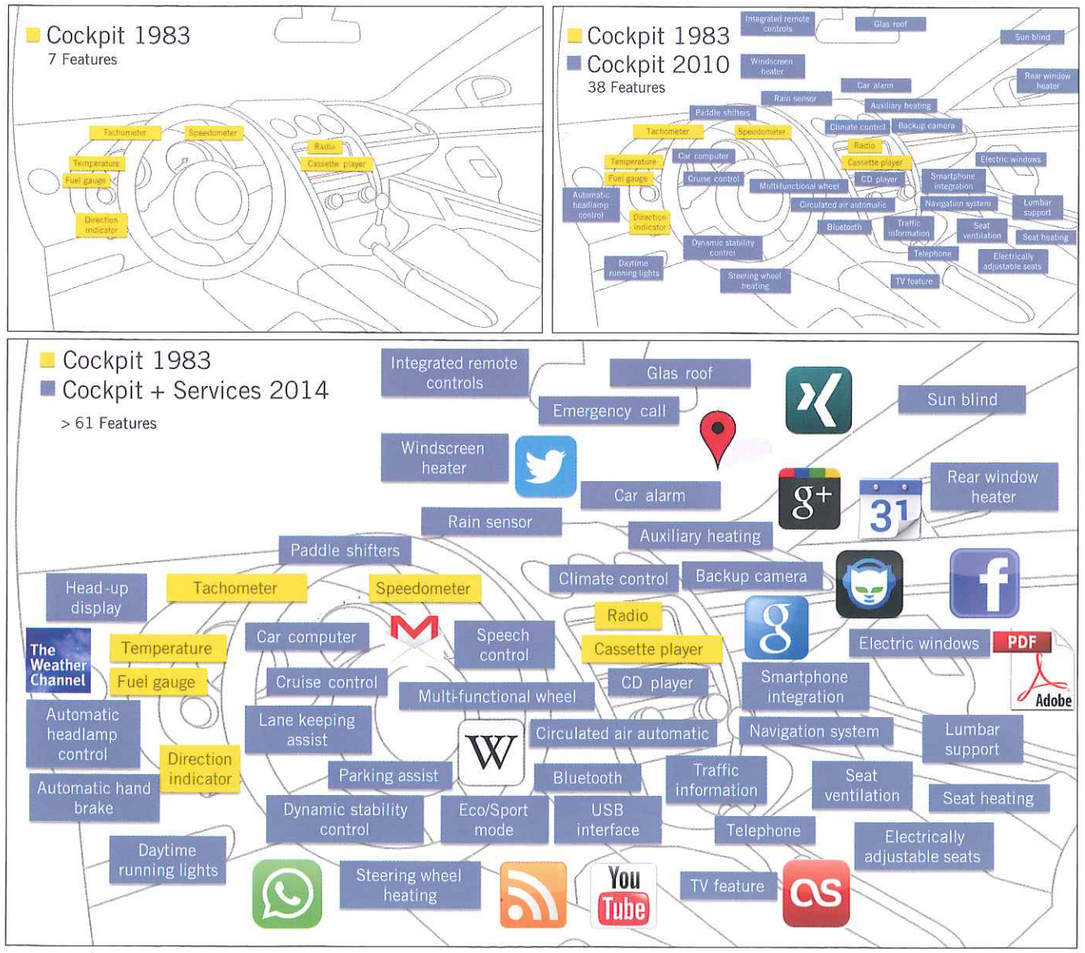
In ❸ the essential properties are compared under scientific scrutiny with current operating systems.

Indicators, light switches and wipers have been relocated to the spokes in the iCS, providing excellent reach, ❹. The display is fully integrated, has a touch function and is positioned at the same level as the conventional instrument cluster. The soft keys with a haptic feedback are arranged laterally, the display is available in various sizes, assigning the context buttons is intuitively recognisable.

Reducing the cockpit to a centrally arranged display and operating unit is a distinct improvement for the driver as well as for safety in traffic. The hands remain on the wheel, the eyes do not have to search the cockpit, the operating unit and all displays are arranged next to each other. Eyes can return quickly to the road.

This means that the warning and information icons, as well as the velocity, navigation and infotainment are concentrated on one display. This is required in a dynamic form, depending on the traffic conditions. As it does not make sense nor is it feasible to permanently display all information, the steering wheel offers several modes, which can be activated by the laterally arranged buttons.

Bringing together all functions in the steering wheel represents a challenge:



❷ Rise of function number for the communication in the driver's environment 1983 (top left), 2010 (top right), and 2014 (bottom) with network services

					
	PROTOTYPE 2	**PROTOTYPE 3**	**SALOON MID-SIZE EXECUTIVE CAR**	**SUV MIDDLE CLASS**	**iCS**
Feature	**Touchscreen, keys, rotary knob**	**Keys, softkeys**	**Multifunctional wheel, instrument cluster with additional information, display and control console**	**Multifunctional wheel, instrument cluster with additional information, touchscreen**	**Touchscreen, keys, scrollwheels, softkeys, paddles**
Input distance	4	4	3	2	4
Output distance	3	3	2	1	3
Haptic feedback	2	4	4	2	4
Eye focus	1	1	3	3	1
Visual design	3	4	4	3	4
(Collaboration)*	(0)	(0)	(2)	(3)	(0)
Display orientation	1	1	4	4	1
Alignment/fragmentation	4	4	2	2	4
Blindly controllable	1	2	3	2	2
Shading of controls by operating	1	4	4	1	4
Conventions and standards	1	1	3	4	1
Directness	3	3	2	3	3
Personalisation	4	4	1	1	4
Tolerance towards influence of the environment	2	3	4	4	3
Efficiency	3	3	3	3	4
(Visual) obstruction when turning the steering wheel	4	4	3	3	4
Total score (max. 64)	37 (37)	45 (45)	45 (47)	38 (41)	46 (46)

*Collaboration relates to the accessibility of the controls in the centre stack for the co-driver, which is not possible with the driver-centred concept of use in the iCS

Rating scheme:
0 ... contradicts the feature in any kind
4 ... complies the feature in any kind

❸ Comparison of two prototypes and two standard driver's operating systems with the new interactive steering wheel iCS

Arranging all operating elements and displays relatively close to the driver presents an advantage, but the legibility – in particular in the case of presbyopia – could be affected. This can be counteracted by distinct contrast, a coordinated colour scheme, and relevant sizes of the graphical display.

When the steering wheel is turned, all contents on the wheel are also turned, thus making manual operation more difficult, which takes some time getting used to. In this respect the test in the simulator has shown, however, that the rotation of display contents (in this case a numerical display) can be tolerated up to an angle of ±60° at most, and that it makes no difference whether the contents are rotated or remain horizontally aligned. Additionally, distraction is reduced compared to when the display is in the usual position in the centre console [8].

Buttons and scrolling wheels have proved their use as part of the steering wheel, as a test [9] has confirmed, which are also distinctly less distracting than the buttons in the centre console For the first time, the result of the three operating worlds – driver's area, passenger seat and back seat – could be implemented with the iCS for the driver.

❹ Driveable prototype of the iCS interactive steering wheel with fully integrated display which has a touch function and is positioned at the same level as the conventional instrument cluster

ADVANTAGES FOR THE VEHICLE

Concentrating all dashboard functions usually used these days in the steering wheel reduces the number of operating components. This considerably reduces the costs and also the weight. According to comparable variations of equipment, this means a potential saving of between 15 and 35 %. By reducing the interfaces, integrating smartphone functions is made easier, ❺.

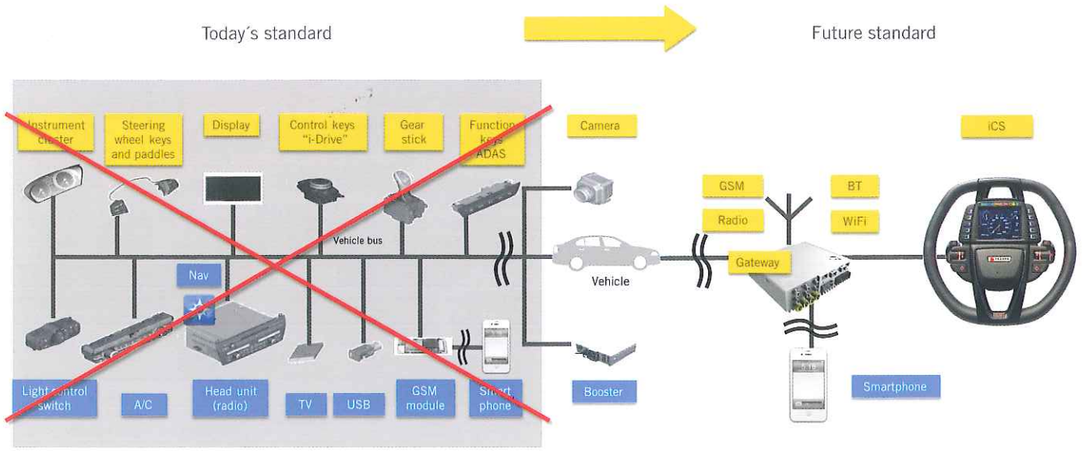
ASCERTAINING THE AIRBAG FUNCTION

One of the points in the specification of developing was to ascertain the airbag function. Extending the communication interface at the steering wheel must not result in restricting the airbag function.

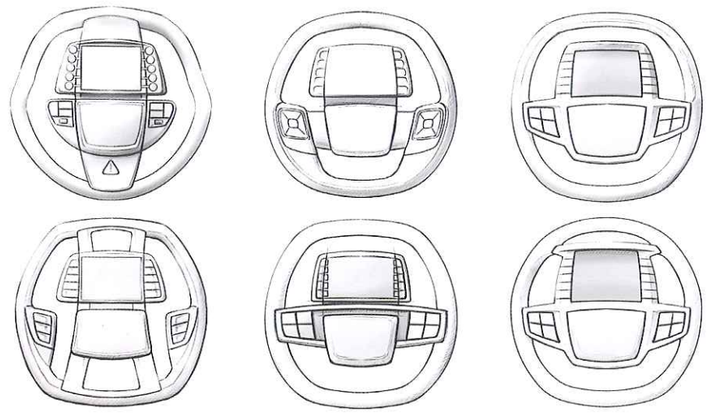
This could only be realised by utilising the so-called vacuum folding in the prototype. Vacuum-folded air bags reduce the folding volume by approximately 40 % compared to the folded volume needed for the same air bag. Takata introduced the worldwide first vacuum-folded airbag for drivers five years ago.

DESIGN IDEAS

During design-finding phase for the interactive steering wheel, it was important for the participating companies to consider all requirements from the human-machine interaction point of view first and foremost. But at the same time, a steering wheel design had to be found showing quite clearly that this is a new form of communication between driver and steering wheel.



❺ Reducing the individual components distributed in dashboard and cockpit (today) by concentrating them in the steering wheel (future)



❻ Design examples with two, but also three or four spokes in the steering wheel

The design for the iCS was developed together with the design office Produktus Industriedesign. With its two spokes it breaks away from the currently used three and four-spoke steering wheels. The examples of the designs in ❻ demonstrate, however, that three- and four-spoke steering wheels are also possible.

PROSPECT

The steering wheel is and remains the human-machine interface between driver and vehicle. The number of operating and networking functions in the cockpit area has increased exponentially over the past few years. Drivers are reaching their cognitive processing limits between traffic and cockpit functions.

Utilising the iCS as an interactive communication steering wheel provides the possibility of counteracting this overload for the driver. It offers for the first time the opportunity for the driver to operate and utilise everything while driving, without taking their hands off the steering wheel. If one looks into the future, the cockpit could become obsolete if it is used.

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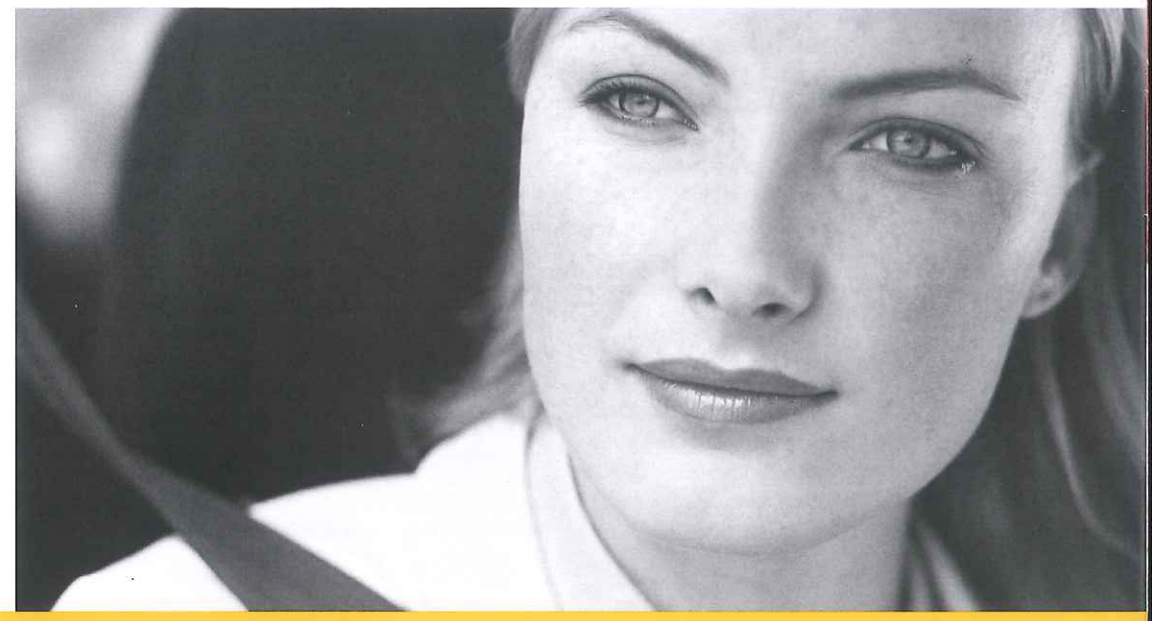

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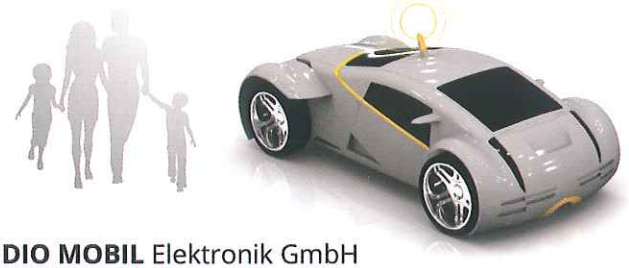

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