ultrahaptics

HAPTICS AND AUTOMOTIVE HMI

Technology and trends report

December 2018

EXECUTIVE SUMMARY

The automotive industry is on the cusp of a 'perfect storm' of trends driving radical design change. Mary Barra (CEO of General Motors) predicts more change in the industry in the next five to ten years than in the previous fifty.

At the same time, increasingly sophisticated haptic technologies are coming to market – including Ultrahaptics' own ultrasonic mid-air technology.

The use of haptics is still under-explored in human-machine interfaces (or HMIs). As such, it offers opportunities to create unique, market-leading products that effectively respond to a changing landscape.

Haptics are an intuitive and non-visual mode of interaction, and are one way of reconciling the contradictory market trends of greater connectivity and better safety. Next-generation automotive HMI will combine haptics with gesture control to reduce driver distraction and 'eyes off the road' time.

Looking further into the future, the quality of the AR and VR experiences on offer in autonomous vehicle cabins will provide a new dimension to brand experience and differentiation between car manufacturers. Haptics – the ability to touch, not just see, virtual objects – will make AR and VR experiences more immersive and intuitive.

At Ultrahaptics, we believe that haptics will change HMIs in ways we are only just beginning to imagine. We look forward to developing the next generation of automotive HMI with you.

Steve Cliffe
CEO and President, Ultrahaptics

CONTENTS

THE FOUR TRENDS DRIVING NEXT-GENERATION VEHICLE HMI

1 CONNECTIVITY AND DIGITISATION

The evolution of the connected car continues to accelerate. Centre stacks feature more and more electronics and larger visual displays, while instrument clusters and heads-up displays (HUDs) are becoming more three-dimensional and interactive.

2 DRIVER DISTRACTION

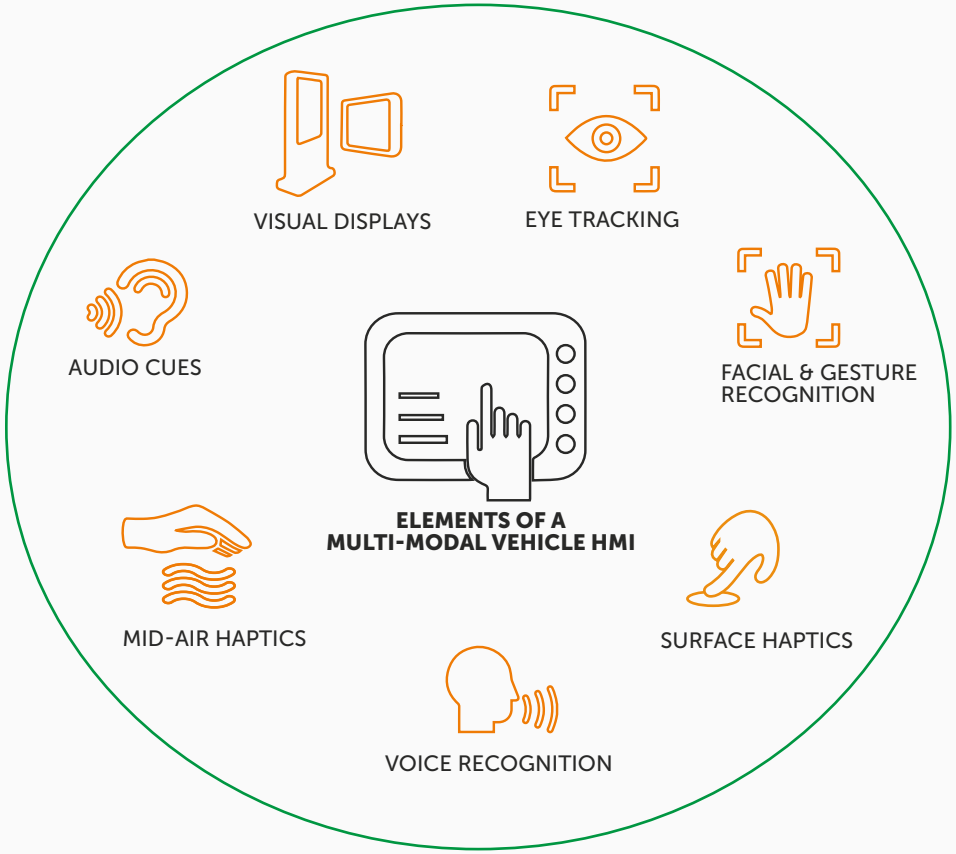
Driver distraction is estimated to contribute to over 3,000 deaths every year in the US alone.[1] Reconciling safety with connectivity is a key challenge driving the development of next-generation vehicle HMI.

3 MULTI-MODAL INTERFACES

We increasingly understand that for interfaces to be intuitive, they have to be multi-modal. Future vehicle HMI will leverage multiple new technologies and machine learning to fuse inputs and outputs targeting different human senses.

4 AUTONOMOUS DRIVING

It is widely accepted that autonomous vehicles will be a commercial reality sometime in the 2020s. Cabins will become mobile extensions of our future immersive workspaces and virtual social environments, and passengers will expect to interact seamlessly with family, friends and colleagues, wherever they are.



"Nearly 70 percent of US adults say that they want the new technology in their vehicle, but only 24 percent feel that the technology already works perfectly."

AAA survey, 2017[2]

[1] https://www.nhtsa.gov/risky-driving/distracted-driving
[2] http://newsroom.aaa.com/2017/10/new-vehicle-infotainment-systems-create-increased-distractions-behind-wheel/

STRENGTHS AND LIMITATIONS OF HAPTICS IN AUTOMOTIVE

Our senses complement each other and are designed to work together.[3]

Incorporating haptics into control systems complements the primarily visual task of actually driving a car. Adding mid-air haptic feedback to gesture control has been shown to reduce "eyes off the road" time and increase accuracy.[4]

Humans also respond instinctively and emotionally to haptics. Haptic warnings are hard to miss and drivers react quickly to them. Vibrotactile haptic technology in advanced driver-assistance systems (ADAS) has been shown to improve lane-keeping by 30%.

Haptic technology is also an effective way of increasing people's sense of control[5] and connection. Drivers express a preference for interfaces that combine mid-air haptic feedback with gesture control compared to just gesture control.[4]

"Non-visual modalities for secondary information make a lot of sense."

Gary Burnett, Professor of Transport Human Factors, Faculty of Engineering, University of Nottingham, UK

HAPTIC STRENGTHS	HAPTIC LIMITATIONS
NON-VISUAL Secondary information can be communicated to drivers and tasks completed without taking eyes off the road.	**SHORT-RANGE** We can see objects a relatively long distance away, but we can only feel things within reach.
INTUITIVE CONTROL Controls incorporating haptic feedback are more intuitive and reduce mental load.	**REQUIRES PHYSICAL CONTACT** Until recently, touch-based interfaces required physical contact with a screen or other device.
PERSONALISATION & PRIVACY Haptic technologies can transmit information to the driver alone, without disturbing passengers.	**LIMITED BANDWIDTH** Detailed information or instructions cannot be conveyed through touch (unless using a specialist language such as Braille).
SENSITIVITY A 2013 study showed that human fingertips can distinguish a pattern as thin as 13 nanometres from a smooth surface.[6]	**POTENTIALLY INTRUSIVE** Drivers need to have a choice whether or not to receive haptic feedback. This should be a design consideration.
REACTION TIME Reaction times to haptic stimuli are 1.7 times quicker than to visual stimuli.[7]	
ENGAGEMENT Haptics are proven to increase user engagement.[8]	

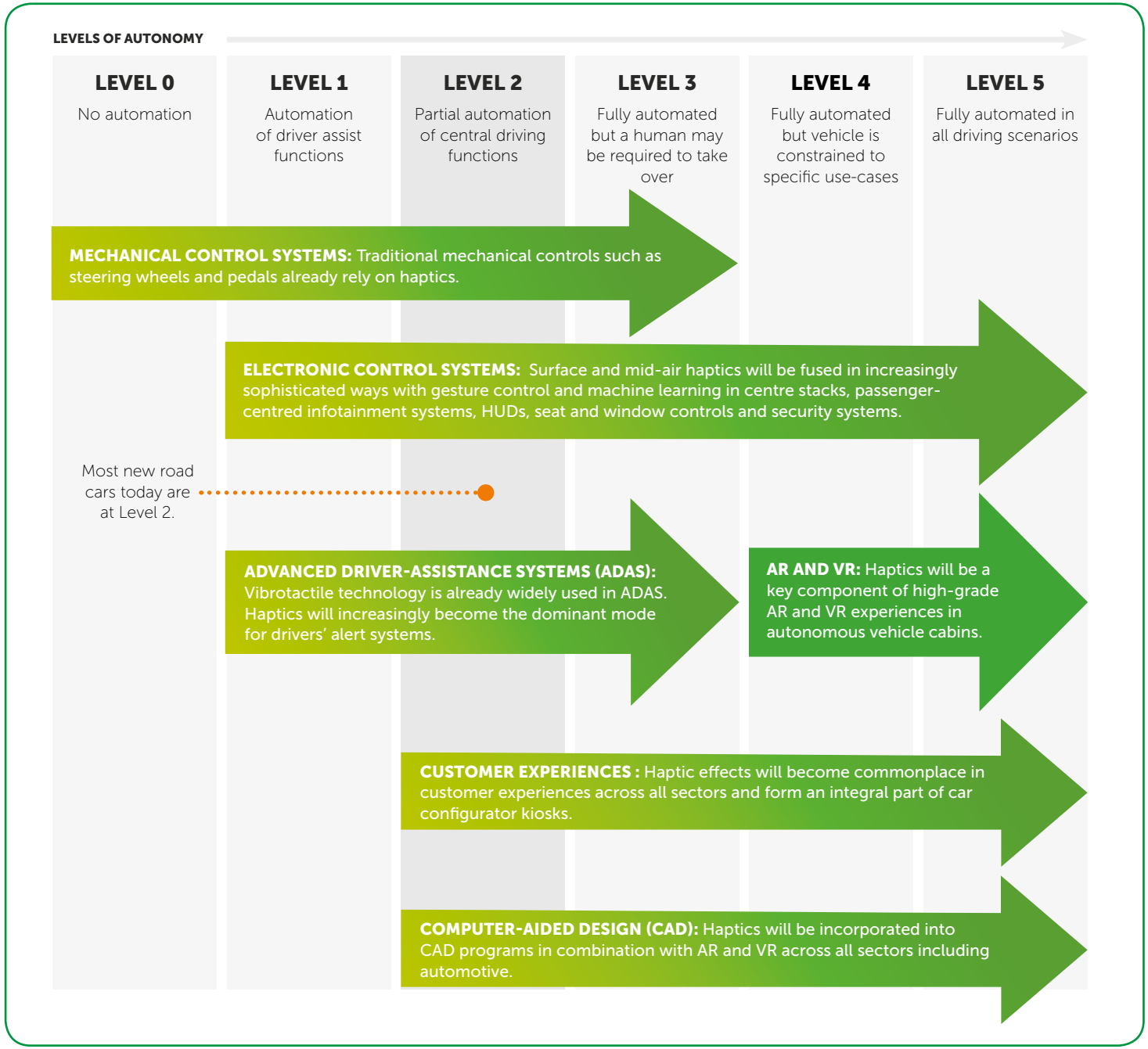
3 See for example Jacko, Julie A., ed. Human computer interaction handbook: Fundamentals, evolving technologies, and emerging applications, CRC press, 2012 | 4 Kyle Harrington, David R. Large, Gary Burnett, and Orestis Georgiou. 2018. Exploring the Use of Mid-Air Ultrasonic Feedback to Enhance Automotive User Interfaces. In Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '18). ACM, New York, NY, USA, 11-20. DOI: https://doi.org/10.1145/3239060.3239089 | 5 https://dl.acm.org/citation.cfm?id=3131726.3132045 | 6 https://www.kth.se/en/aktuellt/nyheter/fingertopparnas-betydelse-for-framtidens-mobiler-1.413913 | 7 Cornelio Martinez, Patricia Ivette, et al. "Agency in mid-air interfaces." Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems", ACM, 2017. | 8 https://www.ultrahaptics.com/news/blog/people-prefer-haptics-in-digital-signage/

HAPTICS AT DIFFERENT LEVELS OF AUTONOMY

The sense of touch has been instrumental in the development of our tools and technology. Drivers already rely on haptic feedback every time they turn a steering wheel or press a pedal.

However, creating tactile sensations through electronics is a relatively new field. Today, consumer electronics are moving beyond simple vibrotactile effects, force feedback devices are increasingly sophisticated, and ground-breaking technologies such as ultrasound-based haptics are entering the market.

As automotive design evolves through different levels of autonomy, legacy haptics such as mechanical control systems and basic vibrotactile and surface haptics will be combined with and eventually supplanted by these new technologies. Haptics will become fully integrated into vehicle HMI (and also car configurator kiosks and automotive design software), enabling manufacturers to deliver increasingly intuitive, personalised and innovative user experiences.



THE UNIQUE POWER OF ULTRASONIC MID-AIR HAPTICS

HOW MID-AIR HAPTICS WORKS

Ultrahaptics' patented algorithms modulate ultrasound waves to create haptic sensations in mid-air. No controllers or wearables are needed: the "virtual touch" technology uses ultrasonic transducers to project shapes and textures directly onto the user's hands.

Ultrahaptics' technology means that every cubic centimetre of the space within a car can potentially be turned into a programmable haptic interface.

In-car installations typically include an array of ultrasonic transducers mounted under the fascia of a product or in a separate control panel and combined with a hand-tracking system. They can provide the sensation of touch up to a metre away from the surface. The accuracy of the sensation is less than a finger-width apart, and can track hand position, hand shape and gestures.

CASE STUDY:
Harman

HARMAN combined gesture control, Ultrahaptics' mid-air technology and their custom graphical user interface (GUI) to develop an intuitive system that can control multiple in-vehicle systems, including audio infotainment. The system responds to the driver's gesture commands with tactile sensations confirming instructions have been recognised and accepted.

KEY BENEFITS OF ULTRASONIC MID-AIR HAPTICS

Safety: Reduces cognitive load, driver distraction and 'eyes off the road'.

No physical contact: No touchscreens, controllers or wearable devices needed.

Flexible: Virtual controls and alerts that can change from second to second according to user needs.

Three-dimensional interaction: Allows the development of innovative HMI.

Enables innovative design: Reduces the need for screens, buttons and knobs, enabling sleek, contemporary design solutions.

Product differentiation and wow factor: A ground-breaking technology that makes experiences memorable and products unique.

"Our haptic feedback solution makes the driving experience safer by enabling drivers to keep their eyes on the road while still maintaining intuitive control of infotainment and audio systems."

Stefan Marti, VP, Future Experience, Harman

ACADEMIC STUDY: The value of mid-air haptics in automotive

The results of a recent collaborative study by Ultrahaptics and the University of Nottingham[9] suggest adding mid-air haptic feedback to automotive HMI can reduce error rates, reduces "eyes off the road" time and is preferred by users.

48 participants each did four simulated drives while using four different types of in-car HMI:

- touchscreen
- touchscreen + mid-air haptics
- gesture control
- gesture control + mid-air haptics

Two different types of interactions were tested: a slider bar and button presses.

The study used a medium-fidelity driving simulator with a right-hand drive Audi TT car positioned within a curved screen.

KEY HIGHLIGHTS

Reduction in both total and mean glance duration times (or "eyes off the road" time) when haptics was added to gesture control.

Mean glance duration time under 2 seconds for gesture control + mid-air haptics across both button and slider tasks.

25% decrease in total glance time on the slider task when using gesture control + haptics compared to a touchsreen.

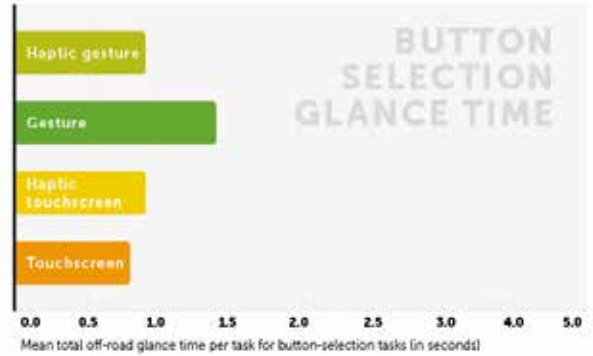
39% of participants were able to perform tasks with no off-road glances at all.

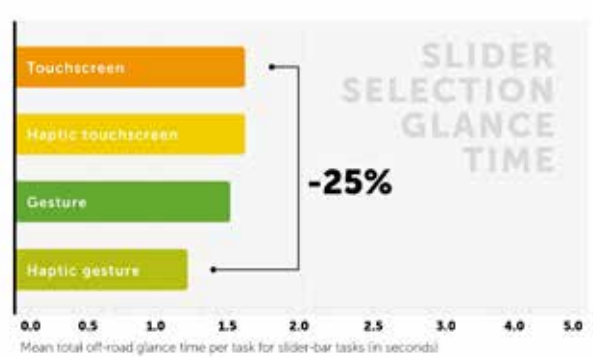
3x greater accuracy on the slider task when using gesture control + mid-air haptics compared to a touchscreen.

Users preferred gesture control + mid-air haptics over both gesture control alone and touchscreens.

"You don't even need to look, you can kind of feel. So the haptic feedback helps with that."

Study participant





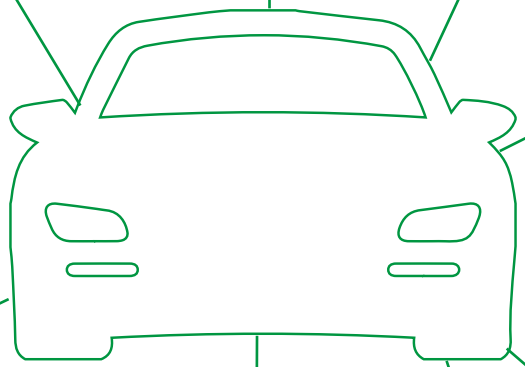
9 Kyle Harrington, David R. Large, Gary Burnett, and Orestis Georgiou. 2018. Exploring the Use of Mid-Air Ultrasonic Feedback to Enhance Automotive User Interfaces. In Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '18). ACM, New York, NY, USA, 11-20. DOI: https://doi.org/10.1145/3239060.3239089

CONTROL. REACT. EXPERIENCE.
Uses of ultrasonic mid-air haptics in automotive

HEADS-UP DISPLAYS (HUDs)
Enable drivers to reach out and touch virtual controls and alerts in front of the steering wheel.

CENTRE CONSOLE CONTROLS
Create a three-dimensional zone of interaction in mid-air above the centre console. Intuitive control of air-conditioning, navigation, media and other systems while keeping eyes on the road.

DRIVER MONITORING & ALERTS
Leverage mid-air haptics within sensor fusion systems to create flexible, discreet and effective ADAS.



AUTONOMOUS VEHICLE CABINS
Generate mid-air tactile sensations in any zone within automotive cabins of the future, and combine with AR and VR.

HIDDEN OR HARD TO ACCESS CONTROLS
Allow simple, intuitive adjustment of seats, windows and other hard-to-find or hidden controls. Create virtual controls that find the driver's hand or provide non-visual confirmation that actions have been anticipated and accepted.

PASSENGER-CENTRED INFOTAINMENT SYSTEMS
Install sophisticated and personalised passenger-centred infotainment systems without overloading the cabin with screens and controls.

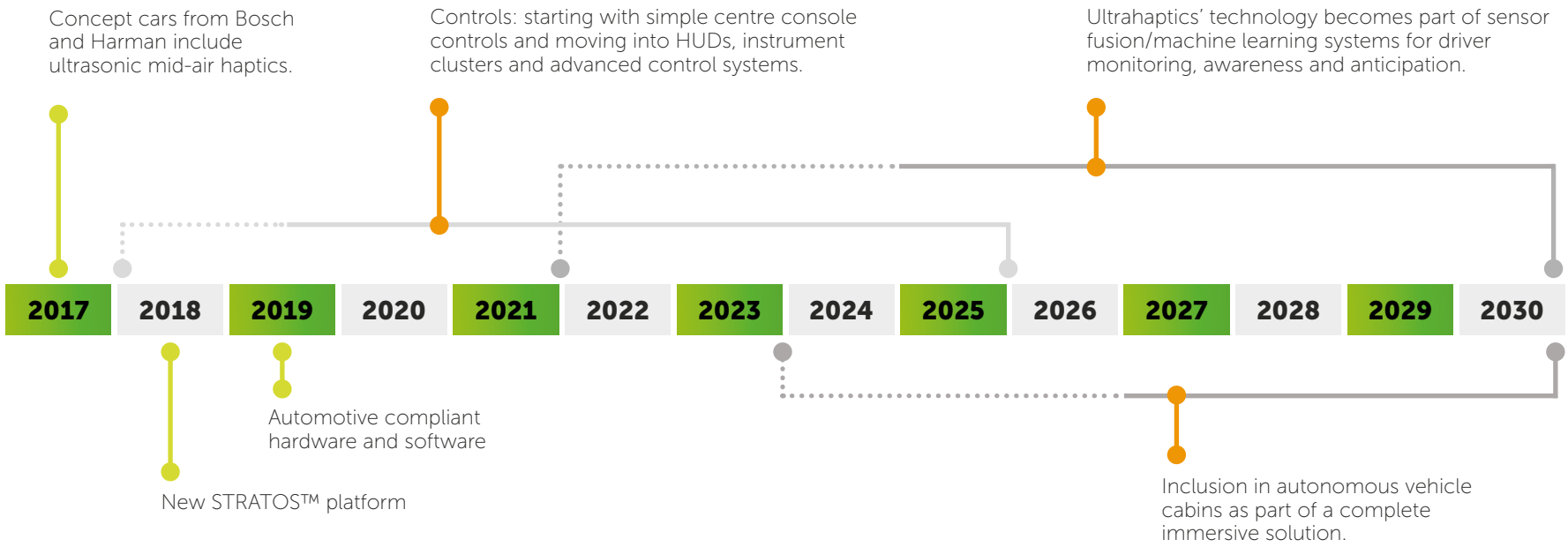
IMMERSIVE PRODUCT DESIGN
Accelerate design and innovation through natural interaction and a richer sense of presence and control.

CAR CONFIGURATOR KIOSKS
Add a memorable extra dimension to customer experiences.

CASE STUDY:
Bosch concept cars

Ultrahaptics' mid-air technology was combined with gesture-recognition infotainment controls in Bosch concept cars shown at CES 2017 and 2018. When drivers reach out to give a gesture command, the system uses tactile sensations to assure them their hands are in the right place. A second haptic response is then given to confirm that the command has been accepted.

COLLABORATE WITH ULTRAHAPTICS
Technology and implementation roadmap



ABOUT ULTRAHAPTICS

Ultrahaptics was founded in 2013 to offer a different type of haptics, which creates the sensation of touch in mid-air using ultrasound. Since then, the company has raised over $80m in three rounds of funding and established a worldwide presence, opening offices in California, Germany and Korea.

Ultrahaptics is currently engaged with blue-chip customers and partners from numerous markets, including digital signage, location-based entertainment and automotive. The first products featuring Ultrahaptics' technology launched commercially in 2017.

PRODUCTS AND PROGRAMS

Ultrahaptics has a number of products and programs that enable customers to work with Ultrahaptics' technology, build prototypes, run user studies, and validate the technology before launching a commercial development program. From plug-and-play development kits and customer programs with sophisticated software tools and expert support, to reference designs and licensing models, we support you from idea to market.

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